

Vol. 29

TRANSACTIONS AND PROCEEDINGS
OF THE
BOTANICAL SOCIETY OF EDINBURGH.

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TRANSACTIONS AND PROCEEDINGS

OF THE

BOTANICAL SOCIETY OF EDINBURGH.

VOLUME XXIX.

INCLUDING SESSIONS LXXXVIII-XCI.

(1923-1927.)

WITH 18 PLATES AND OTHER ILLUSTRATIONS.



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TRANSACTIONS
OF THE
BOTANICAL SOCIETY OF EDINBURGH.

SESSION LXXXVIII

CAREX MICROGLOCHIN, WAHL. A SPECIES NEW TO SCOTLAND.
By G. CLARIDGE DRUCE, LL.D.

(Read 18th October 1923.)

For many years I have been searching for this small sedge in Britain, since its geographical distribution marked it as one likely to occur in Scotland. I have gathered it in Switzerland and in Italy, and last year on the Dovrefeld in Norway. My two visits to Shetland failed to find it, although one rather confidently hoped to discover it there, but the flora of that island group is not arctic.

In July 1923 several members of the Botanical Society and Exchange Club of the British Isles visited Scotland, and among other places they investigated Glen Lyon to see *Carex atrofusca*. On this excursion two members of the party, Lady Davy and Miss Gertrude Bacon, became separated from the others and each found in a different boggy place a sedge which resembled *C. pauciflora*, but which Lady Davy felt was not that species. On returning home she compared her specimens with the figures in Coste's Flore de France and in Blytt's Norges Flora, and concluded that the sedge was not *pauciflora* but *microglochin*. She sent me specimens for verification.

I visited Surrey to obtain from Lady Davy full particulars of the habitat of the plant, and in August travelled to Perth, where Mr. Corstorphine kindly met me and motored me to Glen Lyon. Under the guidance of Mr. Haggart we reached

the Yellow Corrie where the plant was originally gathered on 25th July, and at about 2500 feet altitude we found the *Carex* and tracked it up the grassy slope to nearly 3000 feet, growing here and there in bare, flattish spaces where a small micaceous bog was formed, avoiding the more sloping and grassy places over which water trickles and in which *Carex capillaris* and *C. saxatilis* delight to grow. In these small, blackish, micaceous spaces, where there is little competing vegetation, *C. microglochin* grows with *Kobresia*, *Carex atrofusca*, *C. dioica*, a small form of *C. flava*, *C. Goodenowii*, *Juncus triglumis* and *Eriophorum*. Here, of course, it is unmistakably native. On the wet, grassy slopes between these micaceous bog-terraces grow *Silene acaulis*, *Saxifraga oppositifolia*, *Juncus biglumis*, *Juncoides spicatum*, *Sagina saginoides*, and other alpine species. The higher rocks show *Salix herbacea*, *S. reticulata*, *Cerastium alpinum*, *Pseudothyrium alpestre*, *Polystichum Lonchitis*, and *Juncus trifidus*. On the moorland, a thousand feet below, *Carex pauciflora* was not rare, and grew with *C. binervis*, *C. echinata*, and *Scirpus caespitosus*.

The description of *Carex microglochin* is: Spica floribus fem. 4-10, masc. subquinis; fructibus reflexis, lanceolatis, arista ex ore integro exserta filiformi recta subulatis, semiteretibus, tenuissime striatulis, in Anders. Cyp. Scand., 1849, p. 74. Its nearest ally is *C. pauciflora*, from which it may be distinguished readily by its more numerous female flowers, 4-10 as against 2-4. They are also aggregated in a denser spike, and the fruits are of a darker colour and have a basilar setiform appendage (bristle) longer than the utricle. This is absent in *pauciflora*. The utricle is fusiform-subulate, compressed, attenuated at the base, and is narrowed into a short beak. The root-stock is stoloniferous, but forms denser tufts than *pauciflora*; the leaves are chiefly basilar, are shorter than the stem, and are smooth and setaceous; the spikelet is solitary, terminal, short, androgynous, the males about 6 at the top, the females 4-10 below; the glumes are dull, reddish brown, oblong (in *pauciflora* they are pale and lanceolate); the style short, included, with three stigmas; the utricles are reflexed when ripe, about 6 mm. long, finely nerved, attenuated, longer than the glume, and furnished with a bristle at the anterior base which is longer than the utricle; the achene is oblong trigonous.

DISTRIBUTION.—Canada, Rockies ; Greenland ; Lapland ; North Sweden ; N. and S. Norway ; Iceland ; Savoy ; Piedmont ; Lombardy ; South Tyrol ; Bavaria ; Swabia ; Lithuania ; Austro-Galicia ; Karpathen ; Altai ; Dahuria ; Caucasus ; Himalaya ; Karakorum, Kunawar ; Thibet ; Szechwan ; and now Scotland.

The variety *oligantha* Kuk. reaches South America to Patagonia and the Falkland Isles. The allied *C. Lyonii*, Boott, from the Canadian Rockies differs in its paler utricles.

This important discovery by Lady Davy and Miss Bacon encourages us to hope that other species may yet be found in Scotland.

SCOTTISH TARAXACA. By G. CLARIDGE DRUCE, LL.D.

(Read 17th January 1924.)

For some years very close attention was paid to the British Hawkweeds, which resulted in increasing the number of so-called species in Britain to nearly 140. Slight though the differences are, yet under cultivation these are not only retained but in some cases accentuated. The species have not been found to hybridise, and the characters remain constant. At that time it was not realised that many if not most of these micro-species are apogamous, and if this can be proved for all the Hawkweeds, their unchanged characters under cultivation to a great degree may be accounted for.

The Dandelions are said also to be apogamous; whether this is a general condition has to be ascertained. No one who has studied them can have failed to notice their extreme variability, nor, if they are cultivated—no difficult matter—can it fail to be observed how stable they are, not only from remaining unchanged in changed conditions, but how truly they reproduce themselves. Herr H. Dahlstedt, who was one of the closest workers at *Hieracia*, has also devoted many years' study to the *Taraxaca*, and in the last edition of Lindman's excellent Svensk Fanerogamflora describes 99 species for Sweden alone against 89 *Hieracia*.

For some years I have been working at the subject, and great thanks are due to Herr Dahlstedt for his unwearying kindness in determining many species for me, for his describing the new species, and for examining all the plants reported on here. Up to the present time I have gathered about fifty of these micro-species in Britain, several of these being newly described by Dahlstedt in the Reports of the Botanical Society and Exchange Club of the British Isles.

It is too early to give an account of the British Dandelions with any degree of completeness, yet one may just glance at a few of the plants which have been recorded from Scottish localities.

Dahlstedt arranges the Dandelions into six groups. These are: (1) ERYTHROSPERMA, (2) OBLIQUA, (3) CERATOPHORA (not yet recorded as British), (4) PALUSTRIA, (5) SPECTABILIA,

(6) VULGARIA. When our knowledge of the Scottish species is more complete a definition of these groups will be given and their salient features discussed. For the present, only those species which Dahlstedt has identified will be enumerated.

ERYTHROSPERMA.

The first group, characterised mainly by the red fruits, is represented by *Taraxacum brachyglossum*, Dahlst. in Bot. Not., 1905, a Scandinavian species which has been found at Monifieth, Forfar (Corstorphine); North Berwick; Findhorn, Elgin; Skye; Jedburgh, Roxburgh. This would be named *T. erythrospermum* by many botanists, but it is not so frequent a red-fruited form as the next. Both delight in low, sunny situations on sandy soil, although in Buckinghamshire I once gathered *brachyglossum* on the summit of Ivinghoe Beacon, which is a grassy chalk-down, but on which the turf had been burned by a Jubilee bonfire, and the fruits were probably carried by the wind to the bare patch of soil from the Brickhill neighbourhood some miles away. It is widely spread in Southern Norway, Sweden, and Denmark. It occurs in Northern Germany and in a few localities in Austria, and is adventive in the Eastern United States.

T. lacistophyllum, Dahlst. in Arkiv för Botanik, 1901, occurs in Sweden, Denmark, etc., and is widely spread in England. In Scotland it has been found on Kirkcaldy Links (as *erythrospermum*, Boswell-Syme); on gravel paths in the grounds of Glen, Peebles, and Sands of Barry, Forfar.

T. fulvum, Lindm. f. see Dansk Exkurs-fl., 1906. This species is distributed in Norway, Sweden, Finland, and Denmark. It occurs on the shingle by the Gala, Galashiels, and, although growing with wool-aliens, is doubtless native.

T. proximum, Dahlst. in Bot. Not., 1905. Distributed in Norway, Sweden, Finland, and Denmark, this species has been found on Salisbury Crags, Edinburgh, 1878.

T. laetum, Dahlst. in Bot. Not., 1905. A Scandinavian species extending into Finland and Russia. In Scotland at Kirkcaldy, Fife.

OBLIQUA.

This group resembles the Erythrosperma, but the fruit is greyish-green. It is represented in Scotland by *T. simile*,

Raunk. in Dansk Ekurs-fl., 1906, a Scandinavian species, found at North Berwick, 1904.

PALUSTRIA.

For the present the enumeration of the species under this group is postponed. *T. udum* and *T. palustre* of old British records should be cancelled. It is a well-marked group, of which I have added from the Midland counties (including Oxon and Berks) a new species which Dahlstedt has named *T. anglicum* (see B.E.C. Rep., 1919, p. 567, for full description) and *T. balticum*, Dahlst., hitherto only known from the mainland of Europe (see B.E.C. Rep., 1912, p. 166).

SPECTABILIA.

As the name suggests, the plants under this group are extremely handsome and are better represented in Scotland than in England, but members of the group have been found as far south as Kent, and one of the most striking of them, *T. naevosum*, Dahlst., in Berkshire, etc.

Mr. Beeby first recorded *T. spectabile* as a British plant from the Shetland Isles (where forms of it are common) in Ann. Scot. Nat. Hist., 1907, p. 169, but the name is often used by him in an aggregate sense. He also named a sub-species *Geirhildae* (l.c., 1909, p. 105), but this for the most part belongs to *T. faroense*, as does his *maculigerum*.

T. faroense, Dahlst. A frequent form on the higher hills, Glen Clova, Canlochan, Forfar; Glen Shee, E. Perth; Ben Lawers, Ben Heasgarnich, M. Perth; Braeriach, Easternness; on both sides of Ben Dearg in W. and E. Ross; Ben Laoigh, Argyll; Tongue, Inchnadamph, W. Sutherland; Dunnet, Caithness; near Stromness, Orkney; many places in Shetland, including Spiggie, Loch Girlsta, and Bressay.

T. croceum, Dahlst. in Bot. Not., 1905. A northern species extending to Spitzbergen and Iceland, and in the Faeröes growing in rock-clefts some way up the hills. In Scotland from Corrie Sneachda, Cairngorm, Easternness, 1919, in damp rocky or grassy places up to 3500 feet. (See B.E.C. Rep., 1920, p. 28, for full description.)

T. spectabile, Dahlst. in Bot. Not., 1905. The restricted plant occurs at Cortachy, Forfar; Loch-na-gar, S. Aberdeen;

near Alford, N. Aberdeen; Tomintoul, Banff; Ullapool, W. Ross; Strath Garve, E. Ross; Skye.

T. naevosum, Dahlst. in Bot. Faeröes, iii (1908), 840. A handsome plant occurring in Kirkeudbright; Cortachy, Forfar; Glen, Peebles; Stromness, Orkney. First known from the Faeröes near Kvanhauge, where it was found by Ostenfeld in 1897; it was afterwards found on the Dovrefeld, etc. Dahlstedt thinks that it is an ancient pre-glacial form which before the last Ice Age had its distribution in N.W. Europe and during the same period inhabited the N.W. coasts of Norway, probably at that time free from ice. The English plants differ slightly from most Swedish specimens by the broader and more recurved leaf lobes and by the slightly darker colour of the flowers.

T. naevosiforme, Dahlst. in Arkiv för Bot., 1911, p. 49. A Norwegian species found in Bressay, Shetland, 1921.

T. Johnstonii, Dahlst. in B.E.C. Rep., 1922, p. 774. Several localities in Orkney: Col. H. H. Johnston.

T. maculigerum, Lindb. f. The type is a Danish plant and corroboration is needed for its occurrence in Britain. Of my many specimens none are passed as it by Dahlstedt.

VULGARIA.

T. hamatum, Raunk. in Dansk Exkurs-fl., 1906. In many English localities, and in Scotland from Braeriach, Easternness.

T. Dahlstedtii, H. Lindb. in Act. Soc. Faun. et Fl. Fenn., 1907. This occurs in Sweden, Norway, Finland, and Russia. A modification of the type occurred on river-shingle at Galashiels, Selkirk, which may probably prove a distinct species.

T. tanylepis, Dahlst. in B.E.C. Rep., 1922, p. 237. Sweyn Holm, Orkney: Col. H. H. Johnston.

T. tenebricans, Dahlst. in Arkiv för Bot., 1910. This extends southwards to France. In Scotland at Galashiels, Selkirk, 1907.

As has been indicated, no member of the group *Ceratophora* has yet been recorded as British, but further work will doubtless add to the list of Scottish Dandelions.

ON PRIMULA PAULIANA. By Professor WILLIAM
WRIGHT SMITH. (With Pl. I.)

(Read 15th November 1923.)

A description of this new Chinese Primula has already been published (Notes, R.B.G., Edin., xiv (1923), 51). But as it has been dedicated to a former President of this Society, it is fitting that an account of it should appear in the Transactions. Opportunity is consequently afforded of giving a figure of the plant, taken from a photograph of the type sheet. *Primula Pauliana* is now in cultivation, and flowered in July and August in the Royal Botanic Garden. The flowering specimens show very well the characteristic racemose inflorescence. The original specimens collected by Mr. Forrest indicate a plant of vigorous growth and one which will be of considerable interest in horticulture. The young plants which have flowered this year are somewhat dwarf, but it is anticipated with some confidence that in subsequent seasons the stature and floriferousness of the original will be attained.

Primula Pauliana, W. W. Sm. et Forrest in Notes, R.B.G.,
Edin., xiv (1923), 51.

Species in sectione Geranioides inflorescentiis elongatis laxe racemosis secundifloris atque floribus pallide flavis valde conspicua.

Planta satis robusta 25–40 cm. alta. Folia 3–9 petiolo ad 18 cm. longo pilis articulatis sparsim instructo munita; lamina foliorum majorum ad 9 cm. longa, ad 8 cm. lata, orbiculari-ovata, basi cordata, textura in sicco tenuissima, ad partem quintam subseptemloba, margine grossi-dentata atque ciliolata, supra glabra vel hic illic pilis articulatis sparsim praedita, infra pallidior ad nervos rubidos basi radiantes pilis similibus bene conspersa. Scapus ad 40 cm. longus, gracilis flexuosus supra medium floriferus, pilis articulatis paucis atque pube minuta indutus; inflorescentia elongata laxe racemosa 20–30-flora secundiflora; bracteae 3–5 mm. longae plerumque lanceolatae vel sublineares integrae, nunc oblongae apice 3–4-lobulatae, pubescentes, nonnunquam pedicello suffultae; pedicelli 6–10



Primula Pauliana, W. W. Sm. et Forrest.

W. W. SMITH.

mm. longi ut scapus induti. Calyx 6 mm. longus minute puberulus ad medium in lobos triangulares acuminatos indurato-apiculatos fissus. Corollae pallido-flavae tubus aurantiacus circ. 11 mm. longus anguste cylindricus extra minutissime pubescens obscure annulatus; limbus circ. 16 mm. diametro lobis obovatis alte emarginatis. Stamina in flore longistylis in partem inferiorem tubi corollini disposita, tubum calycis vix superantia, in flore brevistylis ad os corollinum inserta. Ovarium globosum; stylus subexsertus in flore longistylis, in flore brevistylis ovarium aequans atque vix tubum calycis superans, glaber; stigma capitatum. Fructus circ. 9 mm. longus e calyce haud aucto exsertus, oblongus, apice dentibus parvis dehiscens.

“West China:—S.W. Szechwan, in the mountains S.E. of Yung-ning. Lat. $27^{\circ} 30'$ N. Long. $100^{\circ} 50'$ E. Alt. 11,000–12,000 feet. Plant of 9–16 inches. Flowers pale yellow, eye and tube orange. Margins of thickets and forests and on open meadows. Aug. 1922.” G. Forrest. No. 22073. Also Sept. 1922. No. 22452 in fruit.

A striking species of the *Geranioides* series and apparently the only yellow-flowered member of that series. The very elongate lax racemose inflorescence is also an easy mark for recognition. The specific name is in honour of the Very Rev. David Paul, D.D., LL.D., an enthusiastic student of the European *Primulaceae*.

ABNORMAL FRUITS OF *ERYSIMUM CZETZIANUM*, SCHUR.
By M. Y. ORE.

(Read 15th November 1923.)

A remarkable case of proliferation—resulting in the production of a miniature flower within the fruit of a Crucifer—was brought to the notice of the writer this summer, and as such a unique phenomenon is of particular interest to teratologists, a detailed description of these abnormal fruits is here set forth.

These fruits appeared amongst the normal capsules on a plant of *Erysimum Czetzianum*, growing under glass in the Rock House at the Royal Botanic Garden, Edinburgh. The plant, which is a native of the chalky uplands of South-Eastern Europe, had been raised from seed sent from Rumania, and to all outward appearance was a perfectly healthy specimen, with no indication of any malformation in its vegetative organs.

While the great majority of the fruits showed no departure from the normal construction, not a few, however, were characterised by an obvious swelling of the pericarp, about a quarter of an inch above the torus. Outwardly these swellings had the appearance of insect galls, but a closer investigation brought to light a teratological feature of a very uncommon type. When the valves of the siliqua were removed it was seen that, while above and below the enlarged portion of the fruit ripe seeds had been produced, the bulge itself was occupied by a miniature flower, attached to the placenta in the position of a normal seed, and completely enclosed by the distended pericarp.

Unfortunately the supply of material suitable for investigation was somewhat limited, but dissections were made of two of these intra-carpellary flowers, while serial sections were also obtained of the flower *in situ*.

By means of the dissections, it was found that each internal flower was, more or less, a miniature replica of the larger flower, of which it formed an aberrant part. It possessed sepals, petals, stamens, and carpels, although the number of

parts in each whorl did not always correspond exactly with the floral formula of the normal flower—doubtless an outward expression of its unstable constitution.

The calyx was represented by two or three membranous, hooded sepals, more or less coherent and enveloping the other floral organs.

The corolla consisted of three minute, clawed petals, which

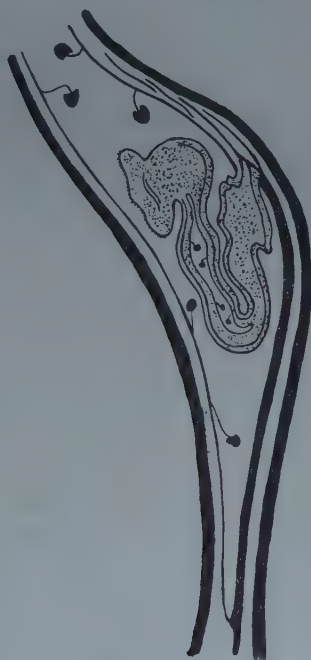


FIG. 1.—Diagrammatic drawing of the lower portion of an abnormal fruit, showing the gynaecium of an intra-carpellary flower, exposed by the removal of the outer floral organs.

were lemon-coloured like those of the species, and of a similar shape.

The androecium numbered six stamens in one of the dissected flowers, and seven in the other, but each stamen was complete with filament and anther, and in the latter mature pollen-grains were observed.

The centre of the pigmy flower was occupied by a miniature gynaecium, with a prominent stigma and an ovary containing ovules, the latter in no way different from those of a normal

flower. Below the carpels, the tissue was enlarged to form a torus from which the other parts of the flower had arisen in regular succession.

The whole flower hung suspended from the ovarian wall on a bracket-like attachment, and at first sight gave the impression of having been developed from the placenta in place of a normal ovule.

That such a metamorphosis of the ovule could have taken place was unthinkable, and an alternative explanation, based on the principle of proliferation, was proposed. This interpretation of the phenomenon postulated a continuation of the main flower-axis beyond the point of origin of the carpels, and its "concrecence" with the placental column up to the point where it revealed its axial nature by the production of a flower. In this connection, it is interesting to recall that Payer (1857) maintained that the placenta should be interpreted always as an axial organ.

In order to test the validity of the hypothesis, it was necessary to make a comparative study of the anatomy of the opposing halves of the replum, for, externally, there seemed to be no apparent distinction between them. The valves of one of the abnormal fruits were therefore removed (to facilitate embedding in paraffin), and serial sections were cut transversely through the replum from its base upwards.

The anatomical details revealed by these sections were illuminating, the most significant feature being the distribution of the vascular tissue in the two parts of the replum. In one, the vascular bundle system followed the normal arrangement found in the carpels of the Cruciferae, but in the other—the supposedly axial organ—an additional series of vascular bundles, with inverted orientation, had made their appearance along the inner margin of the replum. Such a grouping of the vascular tissues is characteristic of an axial organ, and forms a marked contrast to the dorsiventral construction of a normal carpel.

It is not unreasonable to conclude, therefore, that the morphologically radial region of the replum, from which these intra-carpellary flowers of *Erysimum* arise, really represents a proliferation of the parent axis which has become concrecent with the carpels after the model of the epiphyllous inflorescence

of a *Helwingia*. No other explanation of the abnormality seems feasible.

Interesting parallel cases of intra-carpellary proliferation have been recorded in plants with free central placentation. A classic example of this type is afforded by *Cortusa Matthioli*, described by Duchartre (1844), in which the placenta was



FIG. 2.—Transverse section through the opposing halves of the replum of an abnormal fruit, showing (1) the normal, and (2) the abnormal grouping of the vascular bundles.

ovuliferous at its base, but at its apex had produced a small flower.

That this phenomenon has been known to occur in plants other than those having free central placentation is illustrated by the remarkable case—recorded by Watson (1849)—of the production of a whole raceme of small flowers within the enlarged fruit of a species of *Anchusa*.

Striking as this phenomenon of intra-carpellary proliferation may appear, it must be remembered, as Masters has pointed out in his *Vegetable Teratology*, that all these cases differ in

degree only from those where the lengthened axis projects beyond the cavity of the carpels.

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THE GERMINATION OF *GARCINIA OVALIFOLIA*, OLIV. By
EDITH PHILIP SMITH, B.A., F.L.S.

(Read 18th October 1923.)

This seed was collected in Nigeria by Captain Robins, and germinated at the Royal Botanic Garden in 1923.

Description of Dry Seed.—The seed (fig. i) is a flattened oval, 10 mm. \times 5 mm. The seed coat is dark brown, slightly wrinkled and very hard. The cotyledons are fleshy, completely fused, with abundant starch in the cells and latex tubes ramifying in every direction. The plumule is 7 mm. long, extending almost the entire length of the seed, cylindrical, slightly flattened, the vascular bundles being collateral.

Germination.—The soaked seed (fig. ii) is 15 mm. \times 6 mm. Plumule 11 mm., tip seen to be in a groove completely covered in by the cotyledons. The radicle shows at the other end as a small knob.

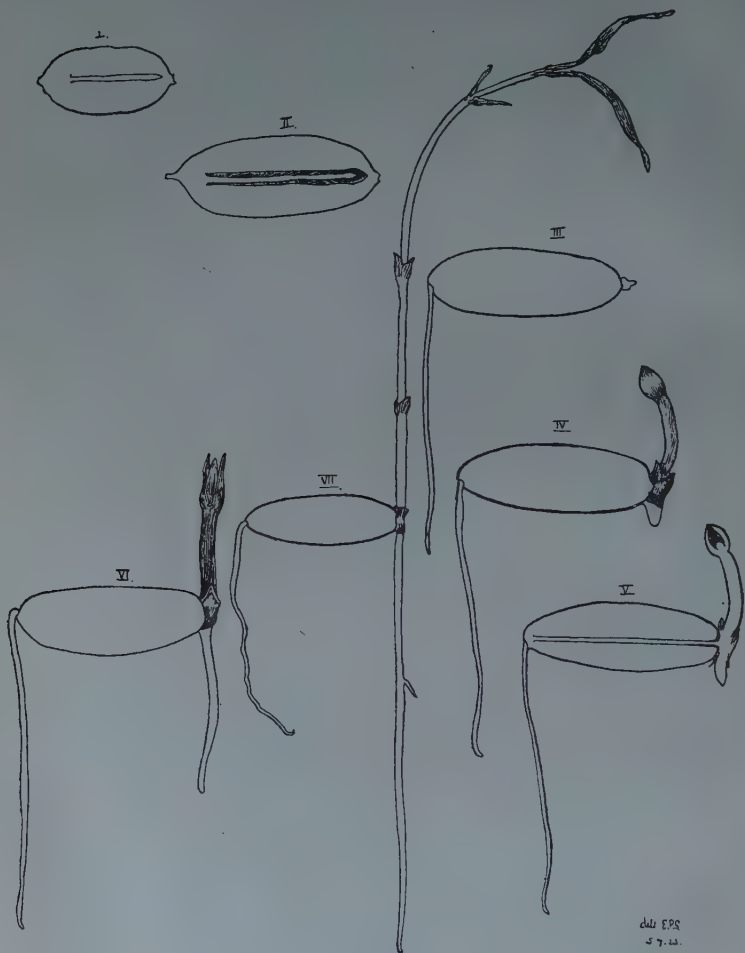
On germination the primary root emerges first (fig. iii). These seeds were laid flat on the soil, so that the primary root grows at right angles to the flat surface of the seed. It reaches a length of 21 mm. before there is any sign of the plumule emerging.

The first pair of leaves forms a sheath round the stem at the point where it leaves the seed (fig. iv). The leaves are small, pointed, and reddish. When the plumule is about 10 mm. long an adventitious root appears at the first node, breaking through the leaf-sheath and growing down into the soil.

The primary root continues to elongate (fig. v), but much more slowly than the adventitious root. By the time the second pair of leaves is visible, the primary root is 25 mm. long and the adventitious root 14 mm. (fig. vi).

At a later stage the primary root ceases to elongate. It begins to shrivel and the adventitious root becomes the functional main root. This is well seen in fig. vii, where five nodes are shown, the leaves increasing in size at each node. The adventitious root is now 60 mm. long and is beginning to branch, while the primary root is only 40 mm. long and shrivelled.

There is a considerable amount of anthocyanin developed, the shoot appearing almost black in the youngest stages. The cotyledons show chlorophyll in the outer layers of cells.



Garcinia ovalifolia, Oliv.

Garcinia Kydia, Roxb., is figured in Wight, *Icones Plantarum*, vol. i, pt. 113.

A similar type of germination is figured for *Garcinia Mangostana*, Linn., by Sprecher, *Rev. Gén. Bot.*, vol. xxxi, pl. 5.

THE ANATOMY AND PROPAGATION OF CLEMATIS. By EDITH
PHILIP SMITH, B.A., F.L.S. (With Pls. II-III.)

(Read 11th January 1924.)

ANATOMY.

I. *Arrangement of Vascular Bundles.*

The number and arrangement of vascular bundles in the stem of *Clematis* appear to be referable to a simple standard

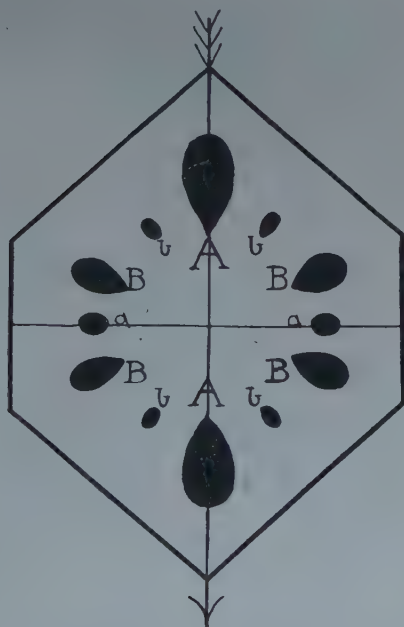


FIG. 1.—Generalised diagram of the fundamental vascular pattern of the stem of *Clematis*, showing twelve foliar bundles: A represents the median leaf-trace bundle; B the lateral leaf-trace bundle, in their passage through the first internode after entering the stem: a, b, the similar bundles from the next node above (*i.e.* in the second internode).

type, from which the variants can be derived by increasing complication or in a few cases by reduction. There are no “cauline” bundles, the whole vascular supply being derived from the leaf-traces. The phyllotaxis is opposite and decussate, and at each node two leaf-traces enter the stem,

each trace consisting of one median and two lateral bundles. The stem is hexagonal in section, and shows two axes of symmetry; one (slightly the longer) passing through the median leaf-trace bundles, and the other at right angles to this. The two long axes of successive internodes are thus at right angles to one another. The six entering bundles run through two internodes before losing their identity, giving twelve as the fundamental number of bundles in the stem. This standard type can be expressed diagrammatically for reference, A representing the median leaf-trace bundle, B the lateral leaf-trace bundle, a , b , the similar bundles from the next node above (fig. 1). For comparison with other forms this arrangement can be written as a formula thus:—

$$2A+2a+4B+4b=12.$$

(*Clematis Vitalba* is typical of this 12-form.) The more complicated types are arrived at by the addition of auxiliary bundles to A or B, or by the splitting of b , or both. Thus *C. Armandi*, a form which shows 28 bundles in the stem, can be written as $2(A+2)+2a+4(B+2)+4(b/2)=28$, indicating that A has two auxiliary bundles, that B has the same, while b has divided into two. Again, *C. smilacifolia* (16) can be written $2(A+2)+2a+4B+4b=16$. For a series of transverse sections through the node, and a longitudinal plan of the course of the bundles through the node, see fig. 2 and fig. 3.

The leaf-trace bundles are really triple, as may be seen in a section of the leaf-base, but they fuse completely before entering the ring of bundles in the stem.

The vascular supply for the bud is derived from bundle a , which usually splits into two strands on entering the node, each of which forks twice, giving eight bundles as the primary supply to the bud. These eight bundles resolve into six and form a ring at the base of the bud.

The species of *Clematis* examined fall into two anatomical classes. In one, the number of vascular bundles is constant throughout the growth of the stem: in the other, the number of bundles increases up to the end of the first year's growth, and then remains stationary. The numbers are remarkably but not absolutely constant; if the shoot is growing strongly a bundle may be added, or if it is impoverished one may be dropped, but these cases do not affect the general scheme.

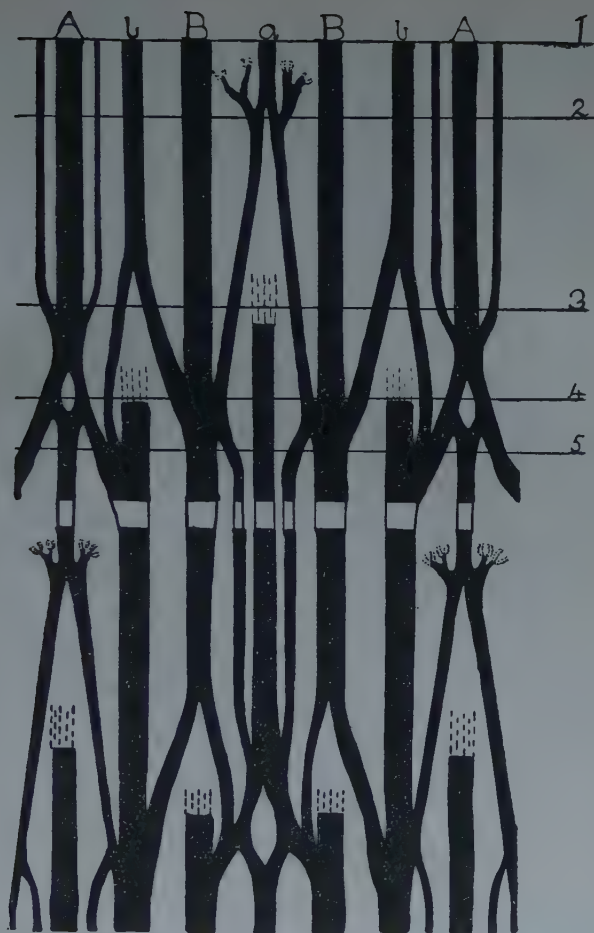


FIG. 2.—Longitudinal plan of the course of the bundles through the node of *Clematis smilacifolia*; one-half of the stem only represented. Numbered and lettered to correspond with fig. 3. Constructed from a series of microtome sections. The vertical scale is slightly exaggerated for clearness. The lower figure shows the vascular supply to the bud.



FIG. 3.—Transverse sections of the node of *Clematis smilacifolia*, numbered from above. Reduced from camera lucida drawings. Numbered and lettered to correspond with fig. 2.

The following table gives the vascular pattern for twenty-five species, ranging from *C. patens*, a soft herbaceous form, to *C. afoliata*, highly xerophytic and without leaves, including *C. Purdomi* (shrubby) and numerous climbing forms.

TABLE I.—VASCULAR PATTERN OF SOME SPECIES OF CLEMATIS.

A. Number of Bundles constant throughout Growth of Stem.

Species.	No. of Bundles.	Habit.
<i>patens</i>	6	herb.
<i>afoliata</i>	12	"
<i>alpina</i>	12	climber
<i>foetida</i>	12	"
<i>Hilarii</i>	12	"
<i>lasiandra</i>	12	"
<i>Meyeniana</i>	12	"
<i>montana</i>	12	"
<i>napaulensis</i>	12	"
<i>orientalis</i>	12	"
<i>Purdomi</i>	12	shrub.
<i>ranunculoides</i>	12	herb.
<i>Spooneri</i>	12	climber.
<i>uncinata</i>	12	"
<i>Vitalba</i>	12	"
<i>cirrrosa</i>	16	"
<i>Delavayi</i>	20	shrub.
<i>indivisa</i>	20	climber.
<i>recta</i>	22	herb.
<i>grewiaeflora</i>	24	climber.
<i>heracleifolia</i>	24	shrub.

B. *Number of Bundles increasing throughout the First Year's Growth, then constant.*

Species.	No. of Bundles.	Habit.
Armandi	12-20-28	climber.
smilacifolia	16-20-28	"
Forestii	24-30	"
Flammula	26-42	"

II. *Description of Tissues : Primary Stem.*

Epidermis.—Thin walled, with thin cuticle (except in *C. afoliata*), small amount of chlorophyll, and few stomata.

Cortex.—(a) Collenchyma occurs as beautifully defined strands opposite the major ridges of the stem.

(b) Chlorenchyma: simple, regular rounded cells, containing chlorophyll and starch.

(c) Starch-sheath: well marked in primary stem. It is differentiated as a definite layer a short distance behind the actual growing-point. At the immediate apex the starch is distributed generally through the tissues. The starch-sheath arches in the bundles and crosses the medullary rays: it consists of a single layer of cells opposite the bundles, but may increase to two or three cells opposite the rays. In the youngest internodes starch is only found outside the sheath. At the node the starch-sheath breaks down, the first gaps being opposite the insertion of the buds. The sheath contracts till it is only visible as an arc subtending the A-bundles, while the starch (which has hitherto been confined to the cortex) passes down the medullary rays into the pith. As the ring of bundles re-forms below the node, so does the starch-sheath link up, and when it is once more complete the bulk of the starch is once more in the cortex. As the stem gets older, starch gradually accumulates in the medullary rays and pith, but the starch-sheath is still definitely visible up to the end of the first year's growth, after which it is cut off by the first periderm. The possibility that the starch-sheath is the equivalent of an endodermis will be considered in the section on propagation.

Pericycle.—A band of eight to ten cells, which is differen-

tiated into arcs of fibres opposite the vascular bundles. In some forms these fibres are united into a continuous wavy band.

Vascular Bundles.—Open, collateral, with large pitted vessels (bordered pits) and much wood parenchyma (pitted, starch storing). The phloem shows a crescentic group of fibres.

Ground Tissue.—The medullary rays are compound, and the primary rays persist throughout the growth of the stem. The parenchyma of the rays and the pith gives a marked phloroglucin reaction, is pitted (simple pits), and stores much starch.

Periderm.—The first cork cambium appears in the pericycle, just within the pericyclic fibres, and forms a complete ring of cork: the cortex is not, however, immediately thrown off.

III. Secondary Thickening.

The arrangement of bundles at the end of the first year's growth persists unchanged. There is no formation of a continuous xylem ring. In old (5–6 year) stems secondary uniseriate medullary rays appear in the xylem masses, resulting in partial cleavage, but even in the oldest stems examined the primary medullary rays could be distinctly seen. In the second and each succeeding year a new phellogen appears in the phloem, producing a periderm which cuts off the corresponding group of phloem fibres. After the first or second year the age of a stem is difficult to determine, because the annual increments in the xylem are ill-defined, and the successive periderms tear away: the number of groups of phloem fibres is perhaps the best guide.

PROPAGATION.

Under ordinary circumstances stem cuttings of *Clematis* will not root at the node; accordingly, in all the species examined, internodal cuttings were taken of wood which had finished the season's growth but was not completely hardened. The cuttings were put in cocoa-nut fibre in a propagating case kept at a temperature of 65°–70° F. In all cases callus formation followed the same course. The first indication was the beginning of meristematic activity in the cortex,

opposite the medullary rays. The new cells thus formed grew over the cut ends of the vessels, and ultimately formed a pad of callus over the whole surface. This was visible in 14-16 days. Some species (as *C. smilacifolia*) formed very little callus and rooted directly through the stem a short distance above the cut. The actual mode of origin of the adventitious roots was the same, whether they came from the callus or not ; in all cases the root originated from the cambium of the stem and pushed its way through a medullary ray to the outside. In one case a root was observed, while still within the cortex, to be fully differentiated into root-cap, dermatogen, periblem, and plerome (fig. 4).

It was found that, by etiolating the stem before taking the cutting, rooting would take place readily at the node. A length of stem of a suitable age and size was selected, and the leaves removed from three or four successive nodes. The stem was then wound with strips of black paper, fixed with a light tie of raffia. The removal of the leaves and the darkening of the stem acted in conjunction to deplete the carbohydrate reserves in that particular region of the stem, while the water-supply was not interfered with. After periods varying from ten days to three weeks the dark paper was removed and the cuttings made. Usually half the number were made at the internode as a control. It was found that the partial blanching, besides making it possible for rooting to take place from the *node*, considerably hastened the rate of rooting at the internode (fig. 5). If, however, the etiolation had been carried on too long, the cuttings were weakened and died off. The best time for any species must be found by trial, as they differ considerably in this respect.

An interesting case of a natural rooting at the node was that of a six-year-old stem of *Clematis montana* which had been lying on the ground in partial shade. The stem was rooting freely at the nodes and not at the internodes (fig. 6). It was seen by examining the roots that the oldest root was five years old, so that the stem must have been prostrate for that length of time and have rooted in its first year. An attempt to repeat this artificially by layering stems of *C. Armandi* for four months was not successful.

A comparison of the etiolated with the normal stem showed a great decrease in the amount of starch present. The xylem

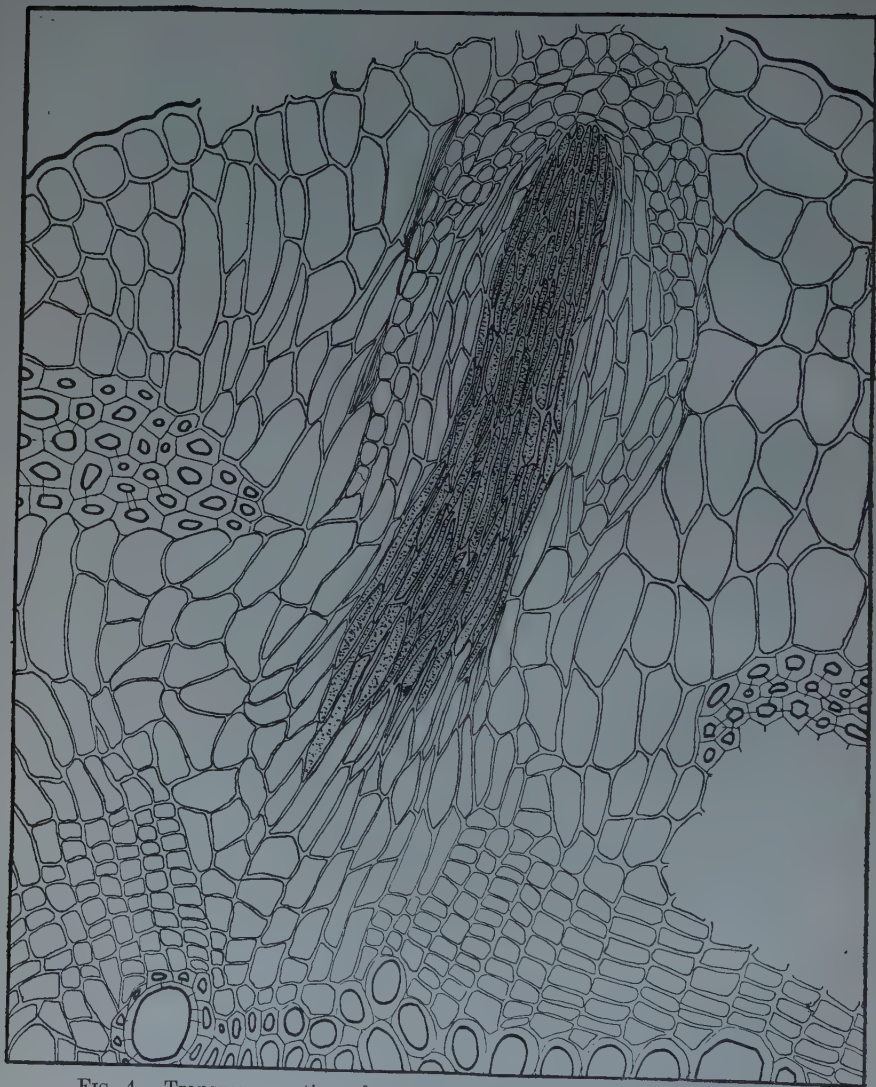


FIG. 4.—Transverse section of a cutting of *Clematis smilacifolia*, showing rooting taking place, 1 cm. above cut surface. The root is originating from the cambium, and is fully differentiated while still within the cortex. Section made fifteen days after cutting was taken.

parenchyma, the pith, and the medullary rays were practically starch-free; the starch-sheath was even more prominent than usual, and the amount of starch in the cortex was greatly reduced. In order to examine the possible relation of the

starch-sheath to an endodermis, the tip of a strongly growing shoot of *C. Forestii* was enclosed in a black paper bag and allowed to grow in the dark for four weeks. No evidence of a Casparian strip could be obtained in this or any of the species examined, so that the starch-sheath cannot be considered as truly equivalent to an endodermis. In any case, the behaviour of the blanched cuttings shows that it has little or nothing to do with the relative ease of rooting.

After etiolation the pericyclic fibres and the pith stained much less strongly with phloroglucin, and the walls of the fibres were reduced in thickness (normal fibre, $10\ \mu$; etiolated fibre, $4\ \mu$). In normal stems of an age suitable for cuttings there was always some starch in the pericyclic fibres, and a great deal in the pith: that is, these cells, in spite of their thickened walls, must be considered to be alive, and therefore it is questionable whether they can be regarded as truly lignified, in spite of their reaction with phloroglucin. There can be no doubt, however, that the process of polysaccharide deposition on a cell-wall is reversible so long as the protoplast remains alive, and that one of the means of reversing the direction of the reaction is by etiolation.

The production of callus, roots, and shoots by an isolated portion of a plant is a process of regeneration, which depends primarily upon the continuation of meristematic activity by those tissues of the plant which have remained embryonic (*e.g.* cambium), or by the resumption of the embryonic state by mature tissues. The process of cell-division is the expression of a series of catenary reactions depending upon the presence in a certain concentration and a certain ratio of carbohydrate and amino-radicles. Only when this carbon-nitrogen balance is maintained can a cell remain meristematic. Under normal conditions (of illumination, etc.) the carbohydrate is always in excess, and it is this excess which determines cell-maturity and the cessation of new growth. If by any means the required C:N ratio can be restored, a mature tissue can be incited to regeneration. Etiolation of the part in question, while still attached to the parent plant and *in full communication with the vascular supply*, should theoretically act in this way, and this is confirmed by experiment. Shading the cuttings in the propagating frame does not have the same effect: carbohydrate is being used up,

but no nitrogen is being supplied and the treatment is merely weakening.

The structure of the node of *Clematis* shows that it presents mechanical difficulties in the way of rooting. There is a great amount of sclerenchyma and very little cambium. It is evident that etiolation acts in two ways: firstly, by "softening" the fibres and the pith, and secondly, by exciting meristematic activity (as in the medullary rays). The resistance of the tissues to the emergent root is lessened, and rooting proceeds quite freely through the leaf-bases.

From the practical point of view the fact that previous etiolation, if not too prolonged, hastens the rate of rooting of internodal (as well as nodal) cuttings is of importance, and may simplify the propagation of some stubborn forms.

SUMMARY.

1. The anatomical structure of the stem of *Clematis* is referable to a simple standard type having 12 foliar bundles. The number of bundles at the end of the first year's growth persists unchanged, as no xylem ring is formed.

2. A starch-sheath is prominent in the primary stem, but cannot be considered as the equivalent of an endodermis.

3. The ground tissue (pith, medullary rays) stains deeply with phloroglucin and stores much starch.

4. Etiolation reduces the starch-content of the whole stem, while the ground tissue and fibres lose their phloroglucin reaction to a great extent, and the walls of the fibres are reduced in thickness.

5. Normal stem cuttings will only strike from the internode, but etiolated stems root freely from the node.

6. Etiolation is considered to act in two ways: (i) by mechanical softening of the tissues, and (ii) by restoring the C : N ratio necessary for meristematic activity.



FIG. 5.—*a.* Stem cutting of *Clematis smilacifolia*, rooting at the node after previous etiolation for eighteen days. *b.* Internodal cutting treated in the same way for comparison. Six weeks after time of cutting.

EDITH PHILIP SMITH.



FIG. 6.—Six-year-old stem of *Clematis montana*, showing natural case of rooting at the node. The stem had been lying on the ground in partial shade for five years, as seen from the age of the oldest roots.

EDITH PHILIP SMITH.

ADDITIONAL NOTES ON THE FLORA OF THE CULBIN SANDS.

By E. J. A. STEWART, M.A., B.Sc., and DONALD PATTON,
M.A., B.Sc., Ph.D.

(Read 1st May 1924.)

1. GENERAL COMPARISONS, 1913 AND 1923.

In Trans. Bot. Soc. Edin., vol. xxvi, part iv, pp. 345-374, the authors described the Flora of the Culbin Sands as observed by them in the year 1913. Since then they have visited the area on several occasions, particularly during the summers of 1922 and 1923. The present contribution is the outcome of observations made during these visits. In the previous paper the area of the sands was classified thus :—

A. Findhorn Bay Margin.

B. Culbin Sandhills Proper.

C. Maviston Sandhills.

In the present discussion the last is omitted and A is included under B. Ten years have wrought many changes in the vegetation as well as in the configuration of the dunes. In the interval extensive devastation by fire has occurred on the western limits, exposing anew dunes which appeared to have been completely fixed by woodland and ground vegetation. These dunes are in various stages of denudation, due mainly to the agencies of wind and rabbits. The large shifting dunes have continued their advance on the woodland to the east. The positions of the smaller dune hollows have accordingly been altered, but the larger basins, such as Buckie Loch, although they have been encroached upon as well as extended, still occupy more or less the same situation.

The plant associations of the shifting dunes have maintained their character during these ten years. The fixed dunes, on the other hand, have been altered; some have disappeared altogether, others are in the process of demolition, others which were being fixed in 1913 are now mature dunes. The gradual sequence of development has been the same as that previously recorded. Additional plants have been noted on the fixed dunes, viz. *Teesdalia nudicaulis*, Br.; *Oniscus*

arvensis, Hoffm.; *Lotus corniculatus*, Linn.; *Hypochoeris radicata*, Linn.

It was, however, in the dune marshes that the greatest alterations were seen. "Peplis Loch" was an alternative name suggested in the last paper for South Loch, but as the result of more recent visits the name can now be applied more appropriately to East Loch, for *Peplis Portula*, Linn., is now absent from the former loch. The reason for this appears to be that East Loch has become wetter, and this is easily accounted for. In 1913 South Loch retained water longer than East Loch, though their altitudes were similar. But in the interval higher dunes accumulated around East Loch, while those bordering on South Loch were very much dissected and lowered. Thus in the vicinity of East Loch the water table is higher, affording a longer-continued water-supply. Moreover, the bottom of South Loch has been elevated to a greater extent on account of inblown sand. In South Loch now the dominant plants are *Littorella uniflora*, Aschers, and *Radiola linoides*, Roth., subdominant being *Rumex Acetosella*, Linn.; *Agrostis alba*, Linn.; *Aira praecox*, Linn.; *Ranunculus repens*, Linn.; *Eleocharis palustris*, R. et S.; *Poa annua*, Linn.; *Cerastium semidecandrum*, Linn.; *Sagina apetala*, Ard.; and *S. procumbens*, Linn. The western portion of both lochs is at the stage of fixation characterised by willows with a close vegetation in which mosses are dominant, accompanied among other plants by *Lycopodium inundatum*, Linn.; *Corallorrhiza trifida*, Châtel.; *Juncus squarrosus*, Linn.; *Drosera rotundifolia*, Linn.; *Eriophorum angustifolium*, Roth.; *E. vaginatum*, Linn.; and *Erica Tetralix*, Linn. The remainder of both lochs is free from high-growing vegetation except occasional tufts or miniature dunes. In 1913 *Peplis Portula* covered the floor of South Loch.

During the intervening ten years a series of "winter" lochs have been formed between South and East Lochs, which are in various stages of colonisation. They all lie parallel to the direction of the prevailing wind and appear to have been formed primarily by extensive "blow-outs" in the dunes.

With regard to Buckie Loch, in 1913 dense vegetation was recorded on the southern slopes descending to the margin. In 1923 it was found that extensive masses of blown sand from the S.W. had encroached upon the marsh itself and had

overwhelmed this vegetation. That this intrusion had been recent was borne out by the fact that *Iris Pseudacorus*, Linn., was blooming profusely several yards within the sand margin. Little alteration was observed on the north side of Buckie Loch. The loch itself contained less standing water than on the previous visit. The vegetation was nevertheless dense and luxuriant. Additions to the flora of this basin include:—*Ranunculus Lingua*, Linn.; *Radicula Nasturtium-aquaticum*, Rendle et Britten; *Sagina nodosa*, Fenzl; *Radiola linoides*, Roth.; *Peplis Portula*, Linn.; *Apium inundatum*, Reichb. fil.; *Gentiana campestris*, Linn.; *Lycopus europaeus*, Linn.; *Corallorrhiza trifida*, Châtel.; *Listera ovata*, Br.; *L. cordata*, Br.; *Goodyera repens*, Br.; *Narthecium ossifragum*, Huds.; *Carex inflata*, Huds.; *C. echinata*, Murr.; *Lycopodium inundatum*, Linn.

Regarding North-West Lochs the only new feature worthy of note is that the dense birch coppice to the south-east of the area is being overwhelmed by the moving dunes bearing *Ammophila arenaria*, Link, and its associates.

Shingles continue to occupy large tracts within the area and are practically barren except for scattered plants of *Rumex Acetosella*, *Cerastium semidecandrum*, and occasional sandy mounds with *Ammophila*.

No outstanding changes fall to be recorded for the grasslands except that the area towards the south-east has been extended by the cutting down of part of the adjacent birch wood. The branches from these trees are being made use of to fix the sand.

In addition to the natural growth of trees on the Culbins, mention was made in the last paper of the planted woodlands. Reference has already been made to the devastating fire which, during the war (1916), laid waste several square miles of pine woodland. The sand of the dunes on which the trees grew was thus exposed afresh to the winds and this may account to a great extent for the alterations on the configuration of the dunes and hollows to the east. The devastated area had an abundant growth of *Senecio sylvaticus*, Linn., and the above accounts for its sporadic occurrence throughout the dunes to the north and east. Again, at Binsness the felling of birches has enabled the sand to encroach on the fixed dune flats to the east. An indirect result of cutting Binsness pinewood is the introduction of a unique flora. A pond had apparently been constructed to serve as a water-supply for the sawmill.

This now contains a fresh-water flora comprising:—*Peplis Portula*; *Hottonia palustris*, Linn.; *Littorella uniflora*; *Juncus subnodulosus*, Schrank.; *Typha latifolia*, Linn.; *Lemna minor*, Linn.; *Alisma Plantago-aquatica*, Linn.; *Potamogeton polygonifolius*, Pourr.; *Glyceria fluitans*, Br.

In addition to the above, the Forestry Commissioners have planted *Pinus Laricio*, Poiret, and *Ammophila* extensively on the Culbins, especially towards the west, south, and south-east. So far they do not seem to have interfered with the present vegetation, as the planting has been confined chiefly to the shifting dunes (*Ammophila*) and the dune hollows. In addition the Commissioners have attempted to arrest the advance of the sand chiefly by laying down brushwood and erecting hurdles, etc.

Very little alteration was observed on the Findhorn Bay Margin, although a different casual population was noted, due to plants or seeds brought down by the River Findhorn or escapes from adjacent cultivated land. *E.g.* the following, not previously recorded, were found growing on the sandy flats:—*Fumaria capreolata*, Linn.; *Brassica oleracea*, Linn.; *Trifolium dubium*, Sibth.; *Leontodon autumnale*, Linn.; *Anchusa sempervirens*, Linn.

To the west of Buckie Loch and north of the North-West Lochs lies an area not described in the previous paper. It stretches to The E'e, and, although extensive, does not show any gradual transition from a fresh-water type of vegetation to that of a salt-water. Its varied nature may be due to frequent flooding at high tides. It is of a marshy nature, low and hummocky, many of the mounds being fairly extensive. These bear *Calluna* and *Erica*, the subdominant plants on the drier mounds being:—*Achillea Ptarmica*, Linn.; *Campanula rotundifolia*, Linn.; *Juncus effusus*, Linn.; *Polypodium vulgare*, Linn.; *Lycopodium clavatum*, Linn.; while on the wetter mounds *Empetrum nigrum*, Linn., is dominant, and *Lycopodium Selago*, Linn., and *Selaginella selaginoides*, Gray, occur occasionally. There are also *Ammophila*-bearing dunes scattered throughout this marshy area. Here, too, casuals occur in close proximity to the track which traverses the area to the fisherman's hut at the east end of Buckie Loch. These include *Mimulus Langsdorffii*, Donn, and *Matricaria inodora*, Linn.

2. PLANT-SUCCESSIONS.

The pioneer of vegetation on the shifting dunes of the Culbins is, as usual in such situations, *Ammophila arenaria*. It becomes established chiefly at the bases and on the lateral slopes of the loose dunes. How it builds up mounds has been described in the previous paper.

In the shelter among the *Ammophila* stems other plants take hold, such as *Festuca rubra*, Linn.; *Deschampsia flexuosa*, Trin.; *Aira praecox*, Linn.; *Viola canina*, Linn.; *Senecio Jacobaea*, Linn.; *Filago minima*, Fr.; *Cnicus arvensis*, Hoffm.; *Veronica officinalis*, Linn. These are usually plants of the current year.

It is when the surface of the said sand of the mound has thus become somewhat closely covered that mosses and lichens appear. In the previous paper some reference was made to these Cryptogams, and further visits have impressed on us the important part they play in the fixation of the sands.

Polytrichum piliferum, Schreb.; *P. juniperinum*, Willd.; *P. commune*, Linn.; *Racomitrium heterostichum*, Brid.; and *R. fasciculare*, Brid., occupy vacant spaces on the *Ammophila* mounds, and their closely interwoven shoots, which extend deep into the sand, give evidence of the work they have done in fixation.

Hypnum cupressiforme, Linn., aids in forming a compact mat with the surface-sand, and its aerial shoots intertwine with the bases of the phanerogamic plants. This moss also can be traced downwards to a considerable depth.

The lichen, *Peltigera canina*, Willd., covers the sand with its thick, tough thallus spreading among the stems of the upright plants. Cup-Lichens, of the genus *Cladonia*, especially *C. coccifera*, Willd., are common on such mounds, generally below the summit on the leeward face, well sheltered among the other plants. The shrubby *Cladonia furcata*, Schrad., also forms an effective sand-binder.

Gradually from such *Ammophila* mounds may be developed fixed dunes, as described in the previous paper.

The possibilities of an increase of this process of fixation on the Culbins have been extended artificially by the recent planting of 400 acres of barren shifting dune with *Ammophila arenaria* by the Forestry Commissioners.

Fixed dunes may also develop from *Ammophila* mounds naturally formed in the dune-hollows, the growth of the vegetation keeping pace with the increase of the dune.

Other plants initiate the formation of mounds of more or less close vegetation in the dune-hollows.

Salix repens, Linn., forms close mats over the tops of low mounds, especially in the drier parts of the dune-hollows, and on the level where sand is being blown in just in front of an advancing dune.

Calluna vulgaris, Hull, and *C. vulgaris*, var. *pubescens*, Hull; *Filago minima*, Fr., and *Viola canina*, Linn., become associated with *Salix repens*. On the sides of the mounds there is often a compact growth of *Polytrichum piliferum*. In many cases nothing shows above ground but the capsules and the tips of the topmost leaves of the gametophyte.

Cup-Lichens, as on the *Ammophila* mounds, fill the spaces at the leeward end, and the shrubby *Cladonia sylvatica*, Hoffm., and *Cetraria aculeata*, Fr., grow among the stems of *Salix repens*. *Parmelia Physodes*, Ach., a foliose lichen, also spreads, closely intermingled with the Willow and other plants.

The upright growth of the vegetation of these mounds in front of an advancing dune keeps pace with the accumulation of sand inblown from the dune. The number of species is seldom much increased. The mounds remain typically low and undulating. They gradually become buried under the advancing dune.

Where the *Salix repens* association is not imminently threatened and the inblowing sand is less, the Willow and Ling assume a taller habit, and usually have as associates grasses, such as *Deschampsia flexuosa*, *Agrostis*, spp., also *Senecio sylvaticus*, *S. Jacobaea*, *Lotus corniculatus*. The whole area may then become a continuous typical fixed dune.

As the dune becomes higher and drier, the habitat becomes unsuitable for *Salix repens*. Under such conditions the centre of a clump may die, and the area left bare is then colonised by the species already mentioned.

Where *Salix repens* establishes itself in a wetter dune-hollow, as along the margins of the "winter lochs," it usually has a more luxuriant growth, and soon has associated with it such plants as *Eriophorum angustifolium*, *E. vaginatum*, *Juncus effusus*, *J. squarrosus*, *Lycopus europaeus*. Thus a mound is

gradually formed, around the base of which may be found :— *Lycopodium inundatum*, Linn.; *Radiola linoides*, Roth.; *Montia fontana*, Linn.; *Polytrichum aloides*, Hedw.; *P. commune*, Linn.; *Brachythecium albicans*, B. et S.; *Hypnum Schreberi*, Willd.; *Ceratodon purpureus*, Brid.; *Bryum pseudotriquetrum*, Schwg. The procumbent forms of the mosses twine among the lower branches of the Willow.

A further development takes place on the miniature dune, when self-sown *Betula tomentosa*, Reith. et Abel, grows up, and in its turn may bear corticolous mosses and lichens.

Successions similar to the above, without *Salix repens*, may be initiated by *Calluna vulgaris*, var. *pubescens*, forming close mats raised on low mounds in the dune-hollows.

Similar mounds may also be initiated by *Juncus conglomeratus*, Linn., and *J. squarrosus*, Linn., which begin as small clumps but quickly accumulate sand. As the mound increases, the *Junci* retain the marginal and wetter parts, and the rest of the mound simulates in its flora the *Ammophila* mounds already described as formed in the dune-hollows.

The level sand in the dune-hollows among the mounds of character as above described, and also the flats where shingle is interspersed among the sand, are mainly colonised by *Carex arenaria*, Linn. It spreads outwards from the hollows and takes an early part in the fixation of the bases of the mounds and also of the shifting dunes themselves.

The interspaces among the stems of *Carex arenaria* are usually colonised by *Senecio Jacobaea*, *Juncus squarrosus*, *J. effusus*, *Prunella vulgaris*, *Aira praecox*, *Cerastium semidecandrum*, and *Lotus corniculatus*, also by mosses, especially *Polytrichum* spp., and by lichens, notably *Cetraria aculeata*.

Mosses act also as pioneers on otherwise bare sand. In the damper hollows, where the sand is firm, spores of mosses are deposited, germinate, and the protonemata formed give rise to moss plants. These, in many cases, are able to keep pace with the inblowing sand, and by continued vegetative growth mat the sand together. The surface of the sand does not always remain level, so that small bosses occur from which the topmost leaves of the mosses project. These are suitable places for the germination of inborne seeds, for the mosses retain sufficient moisture for the growth of the seedlings.

Bosses such as these may in many cases form the bases of the mounds already described.

The mosses concerned in this mode of fixation are chiefly *Polytrichum*, spp., and *Philonotis fontana*, Brid.

Where the area remains quite level, a dense carpet of mosses may grow up, and succeed in binding the sand, forming a subsoil for the subsequent phanerogamic plants, as was indicated in the previous paper.

Mosses are also pioneers on the shingle-hollows, particularly *Rhacomitrium heterostichum*, Brid.; *R. canescens*, Brid.; *Hedwigia ciliata*, var. *striata*, Wils.; *Polytrichum piliferum*, Schreb.; *P. juniperinum*, Willd.; *Hypnum cuspidatum*, Linn.

Some of the lichens already mentioned are also pioneers on the dune-hollows. *Cetraria aculeata* is especially important. Probably pieces of the plants growing on the *Ammophila*, *Salix*, and other mounds, and among the stems of *Carex arenaria*, are broken off; the entangled branches of the shrubby, rather spiny thallus, become rolled into somewhat spherical masses, and are driven along swiftly before the wind over the surface of the sand. They are caught by living or dead vegetation and other obstacles or in slight hollows of the sand itself, and start to grow and to arrest the sand in fresh localities. With them are carried portions of other plants and seeds, whereby the dispersion of these also is aided.

Other shrubby lichens, especially *Cladonia furcata*, effectively colonise bare sand.

The foliose lichen, *Peltigera canina*, is a pioneer on sand of various degrees of mobility, and another leafy species, *Parmelia physodes*, spreads rather loosely over moderately hard areas of sand.

Grassland, which is the most advanced stage of fixation by vegetation of the drier dune-hollows on the Culbins, does not in general develop naturally into any form of woodland. There is found an occasional low shrub of *Betula tomentosa* at the sheltered end of a mound, as already described, and taller plants of the same species and of *Sambucus nigra*, Linn., probably self-sown from trees in the neighbourhood, occur here and there on the south-east grassland. Occasional are bushes of *Cytisus scoparius*, Link, and *Ulex europaeus*, Linn.

Juniperus communis, Linn., mentioned in the Act passed after the seventeenth-century sandstorm, but not recorded by

us on our earlier visits, was found in 1923 on the drier ground interspersed through the marshy areas of "North-West Lochs."

Even a small shrub may afford a habitat for a number of species of mosses and lichens. *Hypnum cupressiforme* covers the bases of bushes and trees, and *Orthotrichum affine*, Schrad., grows on the branches. The lichens also are of typical corticolous species.

On a Birch, 1 foot high, were noted, among other lichens, *Parmelia physodes*, Ach. ; *P. fuliginosa*, var. *laetevirens*, Nyl. ; *Ramalina farinacea*, Ach. ; and *Evernia furfuracea*, Mann. The lichens on another tree of the same species, 12 feet high, included, with the above species, *Evernia prunastri*, Ach. ; *Xanthoria parietina*, Th. Fr. ; *Physcia hispidula*, Tuckerm. ; *Alectoria jubata*, Ach., growing upon *Parmelia physodes* ; and such crustaceous forms as *Lecanora subfusca*, Ach., and *L. conizaea*, Nyl. The occasional low bushes of Broom also bear lichens.

East Loch may be taken as a typical example of the dune-marshes. The greater portion of this hollow is under water during winter. The remainder is more or less of the nature of scrub. Towards summer the water disappears and the surface of the sand soon reveals its vegetation. Here the plant associations seem to vary according to the water-content of the sand. In the centre and wetter parts is a pure growth of *Peplis Portula*, Linn., interrupted here and there by small tufts of *Carex Oederi*, Retz. Around this area is a belt characterised by *Littorella uniflora*, Aschers., and with it are associated *Carex Goodenowii*, Gay ; *Sagina procumbens*, Linn. ; and *Carex inflata*, Huds. Another concentric belt occurs beyond, in which *Ranunculus Flammula*, Linn., and *Hydrocotyle vulgaris*, Linn., are dominant with *Juncus bulbosus*, Linn. ; *J. articulatus*, Linn. ; *Myosotis caespitosa*, Schultz ; and *Eleocharis palustris*, Roem. et Schult. Outside this zone *Radiola linoides*, Roth., abounds and is accompanied by *Gnaphalium sylvaticum*, Linn. ; *Juncus conglomeratus*, Linn. ; *Potentilla Anserina*, Linn., indicating an approach to a drier soil. The above zones could easily be distinguished at a distance by their respective colours. Here lichens were scarce, but mosses abundant, including in the wetter places species of *Sphagnum*. On the windward margin of the marsh the vegetation is characteristic of shifting and partly fixed dunes,

and, by the inblowing of sand, mounds colonised by a similar flora are being built up within the marsh itself.

It is towards the western ends of the dune-marshes that the nearest approach to natural woodland is developed on the Culbins, in the form of "scrub" or low wood. The trees, which reach a height of about 10 feet, are chiefly *Betula tomentosa*, Reith. et Abel., and *Salix aurita*, Linn.

Under these trees is developed a ground-vegetation rich in species of phanerogams and mosses, but, like that of the more open marshes, relatively poor in lichens.

Here, besides the typical marsh-plants, occurs *Goodyera repens*, Br., so abundant in the pine-forests of the neighbourhood.

The trees themselves of these dune-marshes, especially the trunks and lower branches, are covered with a luxuriant growth of mosses and lichens.

A considerable part of the Culbin area is occupied by planted woodland, although, as already indicated, less than at the time of our first visits.

The ground-vegetation of the "Birches" near the south-east margin of the dunes is relatively poor and is suffering from the invasion of sand from the advancing dune on the west, upon which is being carried forward the flora of *Salix repens*, *Polytrichum* spp., *Cetraria aculeata*, and other colonisers of sand.

The ground-vegetation of the pine-woods towards Binsness is also relatively poor in species.

On the other hand, that in the "Low Wood," where it approaches the sea on the western border of the Culbins, and, having wide spaces among the scattered old pines, resembles a pine-heath such as is frequent in the older pine-woods of the district inland, the ground-vegetation is also characteristic of such a habitat. It includes *Erica cinerea*, Linn., elsewhere scarce on the Culbins, and *Goodyera repens*, Br.

The mosses and lichens growing on the trees of these planted woods of pine and birch are typical of the same habitats elsewhere in the district, and generally include the same species as those described above for the natural scrub.

SUMMARY.

The chief points brought out by our later observations on the Culbin Sands are :—

1. The major topographical features of the shifting dunes, fixed dunes, and dune-hollows have been maintained.

2. The generally eastward advance of certain of the dunes has continued.

3. The dunes are still continuing their encroachments upon the neighbouring planted woods.

4. Although only the "Culbins Proper" have been examined in these later visits, the number of phanerogams recorded has been increased from 130 species to 250.

5. Owing to the movement of the sand and consequent alterations in the water-table, there have been changes in the character and distribution of the flora of the dune-marshes.

In particular, the large society of *Peplis Portula* in South Loch has disappeared, but the same plant has been recorded in abundance in other marshes where it was not previously found.

Also the rather rare species *Lycopodium inundatum* could not be found in the area where it was previously recorded, but was found locally frequent in other localities.

6. The additions to the species of phanerogams, in particular of rare species, such as *Corallorrhiza trifida*, have been mainly from the dune-marshes.

7. Increased recognition has been compelled of the importance of mosses and lichens in fixation of the sands.

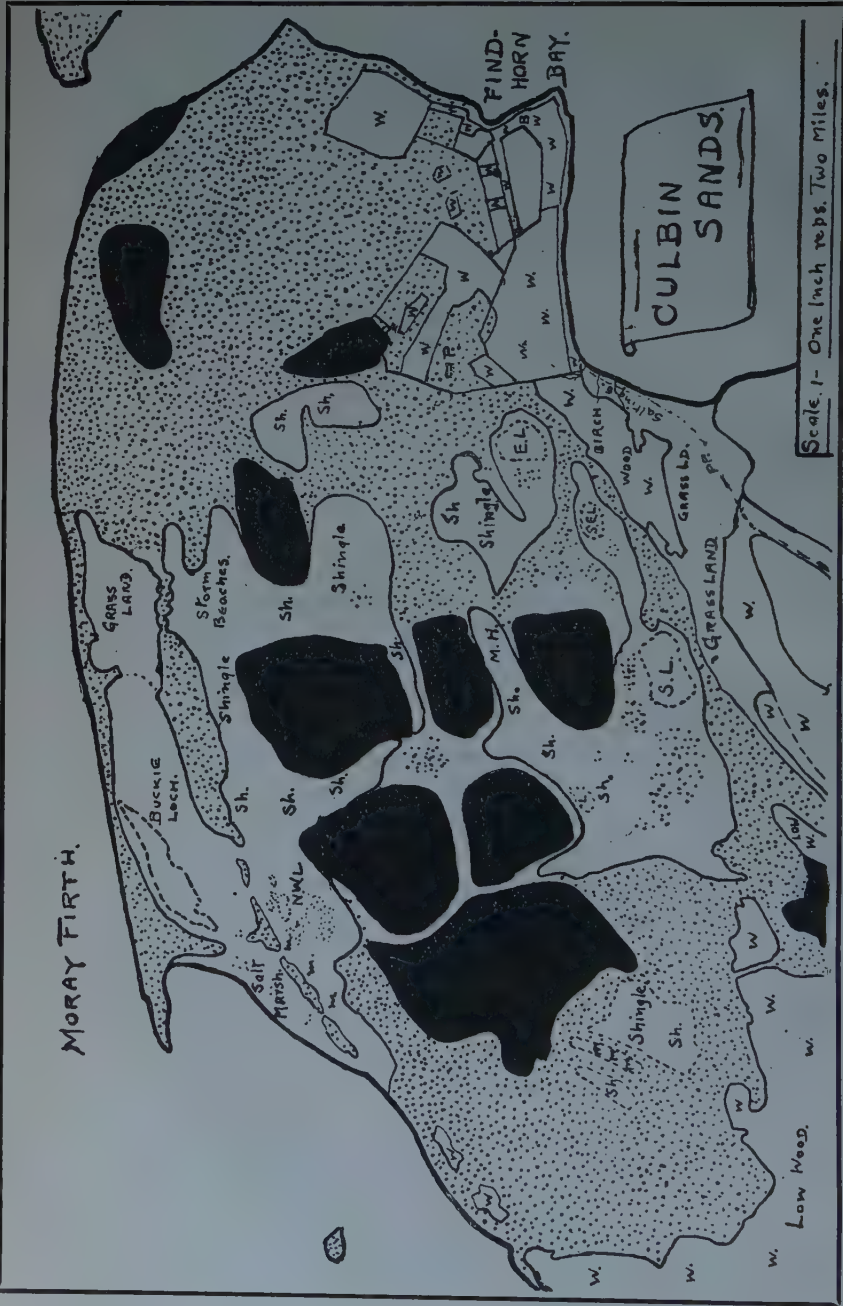
8. The species of mosses and lichens concerned, and their place in the succession of vegetation, are generally in agreement with those described for other dunes in Great Britain.

9. The planted woods of the Culbins have suffered extensively from fire and cutting, with consequent effect upon the distribution of the natural dune-flora.

An indirect result has been the introduction of casuals, including the abundant *Senecio sylvaticus* colonising the denuded sand, and the rare *Hottonia palustris* growing in the artificial pond.

10. Another interference with the natural sand-dune succession has been introduced by the planting of Marram and Corsican Pine by the Forestry Commission. The continuance and success of this scheme may in time change the flora of the dunes completely; but it is in too early a stage to give indication of the effect.

MORAY FIRTH.



Scale, 1- One Inch reps. Two Miles.

KEY TO THE MAP.

S.L.	South Loch.	P.	Artificial Pond.	m.	Marsh.
S.E.L.	South-East Loch.	B.	Business.	■	High Shifting Dunes.
E.L.	East Loch.	Sh.	Shingle.	Stippled area.	Ammophiles and

LIST OF PLANTS ADDITIONAL TO THOSE RECORDED IN
1914 FOUND ON THE CULBIN SANDS.

Ranunculus sceleratus, Linn.; *R. Flammula*, var. *tenuifolius*, Wallr.

Papaver dubium, Linn.

Fumaria capreolata, Linn.

Radicula Nasturtium-aquaticum, R. et B.; *Cochlearia officinalis*, Linn.; *Sisymbrium Sophia*, Linn.; *Brassica oleracea*, Linn.; *Thlaspi arvense*, Linn.; *Teesdalia nudicaulis*, Br.; *Cakile maritima*, Scop.; *Raphanus Raphanistrum*, Linn.

Viola Riviniana, Reichb.; *V. tricolor*, Linn.; *V. arvensis*, Murr.

Lychnis Flos-cuculi, Linn.; *Cerastium semidecandrum*, Linn.; *Stellaria media*, Vill.; *S. uliginosa*, Murr.; *Arenaria peploides*, Linn.; *Sagina maritima*, Don; *S. apetala*, Ard.; *S. subulata*, Presl; *Spergula arvensis*, Linn.; *Spergularia rubra*, Pers.; *S. salina*, var. *media*, Presl.

Montia fontana, Linn.

Linum catharticum, Linn.

Erodium cicutaria, L'Hérit.

Trifolium medium, Linn.; *Lotus uliginosus*, Linn.; *Vicia cracca*, Linn.

Alchemilla vulgaris, Linn.; *Pyrus Aucuparia*, Ehrh.

Callitriche palustris, Linn.

Epilobium parviflorum, Schreb.; *E. montanum*, Linn.

Apium inundatum, Reichb. fil.; *Anthriscus sylvestris*, Hoffm.; *Angelica sylvestris*, Linn.

Galium palustre, var. *Witheringii* (Sm.).

Valeriana sambucifolia, Mikan.

Filago minima, Fr.; *Gnaphalium sylvaticum*, Linn.; *Achillea Ptarmica*, Linn.; *Matricaria inodora*, Linn.; *Senecio vulgaris*, Linn.; *S. sylvaticus*, Linn.; *S. aquaticus*, Hill; *Carduus crispus*, Linn.; *Cnicus palustris*, Willd.; *C. arvensis*, Hoffm.; *Crepis capillaris*, Wallr.; *Hieracium Pilosella*, Linn.; *Hypochaeris radicata*, Linn.; *Leontodon autumnale*, Linn.; *Sonchus arvensis*, Linn.

Campanula rotundifolia, Linn.

Pyrola minor, Linn.

Hottonia palustris, Linn.; *Trientalis europaea*, Linn.

Centaurium umbellatum, Gilib. ; *Gentiana campestris*, Linn. ;
Menyanthes trifoliata, Linn.

Mimulus Langsdorffii, Donn ; *Veronica montana*, Linn. ;
Rhinanthus Crista-galli, Linn.

Lycopus europaeus, Linn.

Plantago major, Linn. ; *P. maritima*, Linn.

Atriplex hastata, Linn. ; *A. Babingtonii*, Woods ; *Suaeda*
maritima, Dum. ; *Salsola Kali*, Linn.

Polygonum aviculare, Linn. ; *Rumex obtusifolius*, Linn.

Urtica urens, Linn.

Quercus Robur, Linn. ; *Fagus sylvatica*, Linn.

Salix purpurea, Linn.

Juniperus communis, Linn.

Corallorrhiza trifida, Châtel. ; *Orchis mascula*, Linn. ;
O. incarnata, Linn. ; *O. latifolia*, Linn. ; *O. maculata*, Linn. ;
Habenaria virescens, Druce.

Narthecium ossifragum, Huds.

Juncus bufonius, Linn. ; *J. compressus*, Jacq. ; *J. Gerardi*,
 Lois. ; *J. conglomeratus*, Linn. ; *J. bulbosus*, Linn. ; *J.*
subnodulosus, Schrank ; *J. articulatus*, Linn. ; *J. sylvaticus*,
 Reich. ; *Luzula pilosa*, Willd. ; *L. multiflora*, var. *congesta*
 (Lej.).

Alisma Plantago-aquatica, Linn.

Eleocharis multicaulis, Sm. ; *Scirpus Tabernaemontani*,
 Gmel. ; *Carex echinata*, Murr. ; *C. flacca*, Schreb. ; *C. inflata*,
 Huds.

Anthoxanthum odoratum, Linn. ; *Alopecurus geniculatus*,
 Linn. ; *Agrostis canina*, Linn. ; *A. alba*, Linn. ; *A. alba*, var.
maritima, Meyer ; *A. tenuis*, Sibth. ; *Deschampsia caespitosa*,
 Beauv. ; *D. flexuosa*, Trin. ; *Glyceria fluitans*, Br. ; *G.*
maritima, Mert. et Koch ; *Festuca ovina*, Linn. ; *F. rubra*,
 Linn. ; *F. rubra*, var. *duriuscula* (Syme) ; *Nardus stricta*,
 Linn. ; *Elymus arenarius*, Linn.

Lastrea montana, T. Moore ; *Polypodium vulgare*, Linn.

Equisetum palustre, Linn.

Lycopodium Selago, Linn. ; *Selaginella selaginoides*, Gray.

REMARKS ON THE MORPHOLOGY AND PROPAGATION OF
GARDENIA SP. By L. B. STEWART. (With Pl. IV.)

(Read 17th January 1924.)

On examining a terminal shoot of this tree it will be found that there are superposed buds on the stem, and that the branch buds are carried up the stems to a distance which depends entirely upon the environmental conditions. It will also be found, however, that although the distance separating them may be considerable, or may only be a few inches, the leaf and bud left behind on the lower position of the terminal shoot are still on the same plane, and until some accident occurs or the main lead is cut off, it is seldom that the bud in the leaf axil develops. Should the terminal shoot be cut off, however, it will then be seen that the buds in the leaf axils develop, and assume the position of the main perpendicular shoot. The branch buds, which are thrown up the terminal perpendicular axis, push out at a horizontal angle, and they go on forming in this manner during the growing season—two pairs of branches at each side of the main axis, opposite and decussate. On these branches are formed branch spines. The spines and leaves are opposite and decussate, but the leaves at their base twist and bring the face surface of the leaf to the light, thus giving the leaves a biplane appearance. The branches attain a length under cultivation of from 18–24 inches, while the tree can attain a height of from 15–20 feet. It might attain a greater height, but as it is a semi-tropical plant, it is not practical to allow it to grow beyond this height as it comes into contact with the glass. It is seldom that more than one pair of buds are developed at the internode, but as many as three pairs of buds have been observed. If the top has been cut off and the two buds have developed, and then these be removed just below the leaf scar, one or both buds at the next internode will then develop.

On taking a branch for a cutting it will be found, after rooting has taken place and the plants begin to get established in the pots, that their growth form is somewhat altered. Instead of making a main perpendicular growth, the growth which takes place in the branches is squat-like branch growth

form—many more leaves are made, and they become larger than in the terminal perpendicular growth. The non-formation of spines in this growth form is peculiar, as it gives it the appearance of being a different plant.

Another peculiarity is that the plant when rooted from the perpendicular shoot goes on growing vigorously and makes no attempt to flower. (A plant of *Gardenia* sp. has been growing in the Royal Botanic Garden for over twenty years to my knowledge, and it has not yet flowered. It is, however, the parent plant of the two plants which are shown in Plate IV.) The branch shoot, however, develops quite a number of flowers every year. After a few years' growth, however, the branch-grown plant produces a sucker (given off from a root) which at once assumes the upright stem form, and very soon becomes the master of the situation. It will then be noticed that the branch plant, at one time healthy, eventually becomes unhealthy and in a very short time dies, unless the sucker plant is removed.

In the Royal Botanic Garden, Edinburgh, a development of the upright stem form from the branch, or from buds formed on the meristem, has never been seen.



Photo R. M. Adams

Gardenia.

L. B. STEWART.

THE BUDDING OF ACER. By L. B. STEWART.
(With Pl. V.)

(Read 15th May 1924.)

The following varieties amongst others which do not come true from seed have been dealt with by the process of budding:—*Acer campestre pendulum foliis variegatis*, *Acer dasycarpum foliis albo-variegatis*, *Acer Pseudo-Platanus flavo-marginatum* (Corstorphine Plane).

Budding of these Acers is usually begun in the third or fourth week of July, and continued until late September, when the bark lifts easily from the stock and the buds are well matured. Care must be taken to see that the buds do not start into growth the same season, but that union is made between the bud bark and wood of the stock. In the spring of the following year, the buds should all be examined, when the stock of the buds which have not taken may be grafted, if it is found necessary. Grafting, however, is not much used for this class of propagation, at least not nearly so much now as it used to be, as it is a much slower method of reproduction. The main point to be observed in budding is to insert the knife right down to the cambium layer, but care must be taken that it does not go deeper, as poor results are obtained if this should happen.

If the wood portion has been cut into, it becomes full of air and after a short time the mark of the knife-cut up the centre of the stem becomes what is sometimes termed chaffed wood, or wood that has lost its vitality. This portion of the wood is no longer a good food conductor, and the bud only gets its food from the outer edge where a proper union has taken place. The buds which are produced as a result of this kind of budding are known as mishriven buds, and are of no use for growing for sale or for planting out. After growth starts the young growths may be supported by the top portion of the stock until the end of the growing season, or till they become hard enough to support themselves. The top portion of the stock is, therefore, left on for two purposes: (1) to act as a support for the first year's growth; (2) to act as a safety-valve, as oftentimes if the stock is pumping hard

the bud is apt to get thrown off, but the top portion of the stock relieves the pressure as the buds above the inserted bud start into growth, thereby using up the superfluous sap. The bud is now in a lateral position, and during the first year's growth a distinct elbow can be seen, where the bud is united to the stock. After the growth has become hard enough to stand without support, the top portion of the stock is removed as close to the bud as possible.

The bud in subsequent years moves, and ultimately attains the perpendicular, thus forming an artificial sympodial axis. This movement of the bud through 90° is brought about by the greater amount of growth on the underside of the bud portion. During this movement the cut end of the stock is forced to the side and becomes apparently lateral.

On looking at a longitudinal section passing through the cut end of the stock (fig. 3), it will be seen that on the bud side the strands of wood are continuous from stock to scion; whereas on the stock side the cut end of the stock makes the connection of stock and scion imperfect, and the wood is cross-grained. This is always the weak portion, and in planting out, the stock end should never face the prevailing winds in case it should be broken.

DESCRIPTION OF PLATE.

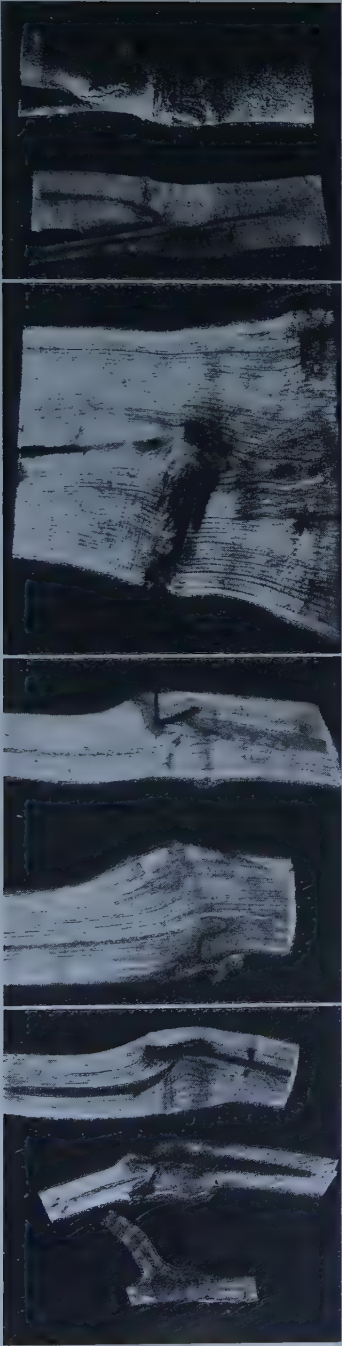
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Fig. 1. Longitudinal sections showing results of careless budding.

Fig. 2. Sections showing stages of bud movement.

Fig. 3. Section showing bud in terminal position.

Fig. 4. A case of budding in which a snag has been left. The section shows the effect of its non-removal.



NOTES ON POTAMOGETON. By ARTHUR BENNETT, A.L.S.

(Read 17th January 1924.)

BRITISH SPECIES AND HYBRIDS.

Some additions to our list are given by Dr. G. C. Druce on the authority of the late Dr. Hagström in Bot. Exch. Club Rep., 1922 (1923), 629.

P. natans × *polygonifolius* = *P. gessnacensis*, Fisch., var. *Richtsfeldii*, Fisch., f. *hibernicus*, Hagst.—Between the Upper and Middle Lakes, Killarney. This is *P. natans*, Linn., var. *linearis*, Syme. Also Scotland: Isle of Colonsay!

P. alpinus × *polygonifolius* = × *P. spathulatus*, Schrad. in Koch et Ziz, Cat. Pl. Palat. (1814), 5, 18. *P. Kochii*, Schultz, Arch. Fl. Fr. et All. (1842), 72. *P. oblongo-rufescens*, Schultz, Flora, xxxii (1849), 230. *P. rufescenti-natans*, Schultz, Jahr. Poll. (1861), 119. *P. alpinus*, β *spathulatus*, Marss. Fl. Neu-Vorpomm (1869), 490. Gren. et God., Fl. France, iii (1855), 313.—Found by Dr. Druce in St. Ouen's Pond, Jersey, 1907. In the original account no actual habitat is given, but Grenier and Godron remark, "M. Schultz regarde cette espèce comme une hybride des *P. oblongus* et *P. rufescens*. Gmelin avait déjà, en 1825, émis une opinion analogue; seulement il considérait comme père le *P. natans*, et le *P. rufescens* comme porte-graine." The original habitat was Kaiserslautern in the Palatinate, whence I have specimens gathered by Alex. Braun. The type specimens are in the Munich herbarium. It occurs in Sweden, Hanover, and Alsatia. Nolte's Sch.-Holstein plant was a form of *P. natans*, and the specimens issued by Dr. Tiselius (Pot. Exsicc. Suec. No. 15a, 28/7/98), are *P. alpinus*, Balb.

P. alpinus × *heterophyllus* = *P. nericius* (Hagst.).—Hagström describes and records this from Sweden and Iceland. Druce, in Bot. Exch. Club Rep., 1920 (1921), 49, records it from the River Don, Aberdeen. Specimens collected by Fryer, 4/9/88, from Farcet Fen Drove, Hunts, under the name *P. heterophyllus*, match the specimens I possess from Sweden from the late Dr. Tiselius, and others from the same place (and date) are the specimens on which Dr. Hagström founded the hybrid.

P. heterophyllum \times *polygonifolius* = \times *P. Seemenii*, Asch. et Graeb., Syn. Mittl.-Eur. Fl., i (1897), 335.—Dr. Druce records this (Bot. Exch. Club Rep., 1922, 631) as the var. *lanceolatifolius* from the River Laune below Killarney. It is known from Sweden as well as another form *subcuspidatus*. Mr. Coles' plant from Kirkcudbright may possibly belong to *P. Seemenii*, as suggested by Dr. Hagström, but my specimen is not sufficient to decide.

P. alpinus, Balb.—Mr. Pearsall sent, from "Peaty drains, Rusland Moss, N. Lancs, v.-c. 69b, 28/7/15," specimens very like those from Japan, being dark in colour like *P. nervigerus*, Wolfg. Although the species varies from bright green (Surrey) to the whole plant suffused with red (Carnarvon), the colour of the Lancashire specimens is rare in Britain. It would be interesting if someone would give a chemical analysis of the floating leaves of *P. alpinus*. Although at times they are a full green, usually in drying the red colour appears, but on being placed in water it disappears again.

P. zosterifolius, Schum.—In American specimens from Mrs. Agnes Chase (Wolf Lake, Indiana, 3/9/1900), the fruits present a very different aspect, shape, and armature to European specimens as figured. They are much swollen, with an umbo at the base of the vertical edge, and the carina of the dorsal edge is crested, with the style almost on the vertical edge. Mrs. Chase's specimens have also several turios or winter buds of large size, sheathed with apiculate leaves. I pointed out these variations to Mr. Fernald of the Gray Herbarium, and he kindly sent several fruits from various States, and these decidedly conform more to Mrs. Chase's specimens than to the European figures. It seems to me the plant should be distinguished as var. *americanus*. Neither Dr. Hagström nor I have been able to see specimens of *P. carinatus*, Kupf. ap. Von Zur Mühlen, Die Pot. Osbalt. in Korr. Bl. Nat. Ver. Riga, 1906, 164, but Hagström places it under *P. zosterifolius*.

P. coloratus \times *pusillus* = *P. perpygmaeus*, Hagst. ex Dr. Druce; *P. lanceolatus*, Sm., var. *hibernicus*, Ar. Benn.—The late Mr. Fryer, in British Potamogetons, 63, regards *P. lanceolatus*, Sm. as *P. heterophyllum* \times *pusillus*, and records it from Cambridge and Anglesey, while the Irish form from Clare and Galway is referred to var. *hibernicus*, Ar. Benn. Dr. Druce (Bot. Exch. Club Rep., 1922, 630) quotes Dr. Hagström in

referring the Irish plant to $\times P. perpygmaeus$, Hagst., who had suggested (*in litt.*, 1919) that while one parent was *pusillus* the second one was *coloratus*. Dr. Druce further remarks that "*P. perpygmaeus* is also the *P. lanceolatus* which was discovered by Mr. Arthur Bennett in Burwell Fen, Cambridge-shire, in 1880."

The history of the Irish specimens is as follows:—The specimens were sent to me, 19/6/96, from the Clonback River, Galway, and in writing to Dr. R. L. Praeger I remarked that the plant was doubtless, in a wide sense, *P. lanceolatus* and possibly the hybrid. I sent specimens to Fryer, who wrote, 5/8/09: "This has been sent to me several times. In all cases I wrote, 'not *lanceolatus* but an undescribed hybrid.'"
A few days later he wrote saying: "It must not go to *lanceolatus*; it will have to stand as $\times P. hibernicus$, Ar. Benn., and be classed with the group of which *P. Bennettii*, Fryer is the type." Still later (24/8/1910) Fryer wrote: "I am growing your Irish *lanceolatus* var. *hibernicus*; it is almost distinct enough to take the latter name only."

With reference to the Cahir River, County Clare, where Mr. O'Kelly discovered the plant, I have the following observations of Mr. O'Kelly in a letter from Mr. Levinge (2/9/91): "With reference to the two *lanceolatus* forms of Potamogeton which are growing in constant running water and submerged to the depth of 3 or 4 feet, growing in dense masses out of the mountain limestone mud, the only water plants growing about it are *Zannichellia palustris*, *Scirpus palustris*, and *Equisetum palustre*; the stream runs very strongly."

Dr. Druce, *l.c.*, p. 630, remarks that "the reddish colour of *coloratus* is also present in *perpygmaeus*, which thus differs from the beautiful grass-green of the Anglesey *lanceolatus*." If Dr. Druce will refer to his own specimens from Anglesey, July 1900, he will see the red colour there, as also turios or winter buds, although Hagström (*Crit. Res. Pot.*, 1916, 150) states that these structures have not yet been observed. In my original specimens from Burwell Fen, Cambs. (4/8/80), there is no trace of any reddish colour, and they were growing with *heterophyllus*, not near it. Certainly the cultivated specimens of the Burwell Fen plants are green, not reddish.

In the Rec. Club Rep., 1875, 138, Mr. C. Bailey records *P. lanceolatus* "growing in patches with *P. gramineus* (hetero-

phyllus) and *P. perfoliatus* in a small brook on Rhôs Lligwy." Neither Davies (1813) nor Griffith (1895) gives *alpinus* from the R. Lligwy. Where *alpinus* does occur is in the south of the county, while R. Lligwy is in the north-east. Davies gave Smith as the locality "Lakes of N. Wales," yet in a specimen from him in Smith's herbarium at the Linnean Society he gives "Between Bodafan and Lligwy, Anglesey, N. Wales, 1807."

The English and Welsh *P. lanceolatus* is certainly different from the Irish plant, which I regard as a separate hybrid, yet the evidence in favour of Dr. Hagström's view that it is *coloratus* × *pusillus* is insufficient, and I consider the problem not yet fully settled. For many years before the hybrid origin of *P. lanceolatus* was suggested, fruit was sought but never found, but in 1882 I forced the plant to fruit in a small pond by placing glass under the spikes. The result was a fruit with a rather long style, being nearly straight with the dorsal side and having two small bosses, one on either side of the dorsal face.

P. foliosus, Raf. AN ALIEN SPECIES IN BRITAIN.

Among plants sent to the Botanical Exchange Club of the British Isles in 1922 were specimens of a pond-weed from the "Exeter Canal at Double Lock, in deep water, Devon, 18/8/1921. Mr. M. D'Urban." These were named *P. pusillus*, but on examination proved to be *P. foliosus*, Rafinesque in Med. Rep., v (1808), 354. *P. gramineus*, Michx. Fl. Bor. Am., i (1803), 102. *P. exstipulatus*, Muhl. Cat. Pl. Am. (1813), 18. *P. pauciflorus*, Pursh, Fl. Am. Sept., i (1814), 21. Morong in Mem. Torrey Bot. Club, iii (1893), 39-47. A. Bennett in Journ. Bot., xxviii (1890), 298. Asch. et Graeb. in Das Pflanz., Hft. 31 (1907), 109. Hagström in Crit. Res. Pot. (1916), 89.

The species is a native of North America, and is recorded from 32 of the 48 States. I have specimens from 18 and have seen others from 7 other States. The species is very variable, although the variations relate mainly to size and breadth of leaf. The extreme form is var. *californicus*, Morong. *P. californicus*, Piper in Fl. Washington, Contr. U.S. Nat. Herb., xi (1906), 637; but Piper in 1915

wrote that he thought Morong was right in calling it a variety. The typical form (ex Morong) from Fresh Pond, Camb., Mass., has the leaves only 1 mm. wide, the Californian specimens having them 5 mm. wide. Morong queries whether this is *P. gramineus*, Michx., but Chamisso and Schlechtendal (Linnaea, 1827, 177) had seen a specimen at Paris in Michaux's herbarium, and Rafinesque says, "Le *gramineus*, Michx. mon *P. foliosus*." The oldest specimens in Europe are (1) in Sir J. E. Smith's herbarium at the Linnean Society, where there are two specimens from "Pennsylvania, Muhlenberg, 1793, No. 55," one of these being *P. Friesii*, Rup., the other *P. foliosus*; and (2) at the British Museum, labelled "Porto Rico, 1824, Hornbeck, leg."

P. foliosus differs from *P. pusillus* by the fruits being 3-keeled on the back, the middle keel winged and more or less sinuate-dentate, varying sometimes with an umbo at the base. No dimensions for width of leaf as a type are possible, so great is the variation, but the Rev. E. J. Hill observes, in Bot. Gaz., 1881, 161, that "typical forms are found at Manistee and Frankfort, Ill.; these have fine, almost hair-like leaves." The Devon specimens differ from the American forms in that they are more diffuse and the varietal name *diffusus* is suggested for them.

FOREIGN SPECIES AND HYBRIDS.

P. alatofructus, Ar. Benn., sp. nov.

Caulis ramosus teres elongatus. Folia amplexicaulia, ovato-lanceolata obtusa membranacea 6-9-nervia, stipulis hyalinis obtusis fugaceis praedita. Pedunculi teretes circ. 3-4 cm. longi inter se aequales; spica cylindrica densiflora e floribus 10-22 subpedicellatis composita; fructus compressus dorso tricarinatus, carina media alata, lateralibus semi-obtusis; carina ventralis rectus; stylus longus apice acutus.

In 1903 Dr. Rendle sent me specimens of a *Potamogeton* gathered in Mandschuria by Dr. Litwinow. These seemed to come under *P. perfoliatus*, L., but certainly different, and I named them var. *mandschuriensis* in Ann. Con. et Jard. Bot. Genève, ix, 1905, 100. Dr. Hagström, in his work on the genus (1916), points out that if the fruit is decidedly winged (not simply from drying) then we have a new species belonging either to *Praelongi* or *Lucentes* according as the leaf margin

is entire or denticulate. The leaf margins are entire, and therefore the species belongs to the group *Praelongi*. It occurs in the Province of Cringiz-chan, and was gathered 23/7/03, Litwinow, No. 3413, and Shungari Pr. Taladshao, Litwinow, No. 3348. Type specimen at British Museum (Nat. Hist.), and co-types at St. Petersburg and in my collection.

P. mandschuriensis, Ar. Benn., sp. nov. *P. acutifolius*, Link, subsp. *mandschuriensis*, Ar. Benn., in Journ. Bot., xlii (1904), 76.

Caulis diffusus ramosus, 40–60 cm. longus. Folia submersa 10 cm. longa 0.5 cm. lata acuta 3-nervia nervo intermedio plus minusve obscuro, stipulis 2 cm. longis. Pedunculus 2 cm. longus; spica 1 cm. longa. Fructus compressus lunato-lentiformis maturitate bullatus, dorso tricarinatus, carina media acuta, carinis lateralibus obtusis; stylus brevissimus.

Type specimens at British Museum (Nat. Hist.), and co-types at St. Petersburg and in my herbarium. The species is related to *P. acutifolius*, Link, to which I referred it as a variety, but the differences are sufficient to distinguish it specifically.

P. brasiliensis, Ar. Benn., *P. lucens*, K. Schumann (non Linn.), Fl. Brasil, iii, 3 (1894), 689, Tab. 119, fig. 2. Ar. Benn. in Journ. Bot., xlvi (1908), 163; xlviii (1910), 150; xxxiii (1895), 373. I had suggested this as a subspecies in 1908, but Dr. Hagström in Crit. Res. Pot., 198 and 266, names it as a species. I have not been able to ascertain that it has been gathered since Gardner's time, c. 1845.

P. fragillimus, Hagst., Crit. Res. Pot. (1916), 202. *P. lucens*, Linn., var. *floridanus*, Ar. Benn., in Journ. Bot., xlv (1907), 374. Hagström makes this a species and I now concur. The local conditions in Florida are peculiar.

P. methyensis, Ar. Benn., sp. nov. *P. Zizii*, Roth., var. *methyensis*, Ar. Benn., in Macoun's Cat. Canad. Pl. (1890), 370. *P. angustifolius*, Bercht. et Presl, var. *methyensis*, Ar. Benn. Journ. Bot., xxix (1891), 151.

Caulis ramosus ad 60 cm. longus. Folia submersa inferiora semi-pellucida lineari-lanceolata 21 cm. longa acuta 7-nervia,

basi lacuna centrali instructa; superiora lanceolata acuta 21 cm. longa 1.25 cm. lata, 15-nervia, inter nervos pellucida; folia natantia 9 cm. longa 3 cm. lata ovato-lanceolata 15-nervia; stipulae 5 cm. longae circ. 24-nerviae. Pedunculus 10-18 cm. longus, spica 3.5 longa densiflora; fructus semi-rotundatus dorso ambitu semi-circularis, carina media semi-acuta, carinis lateralibus indistinctis, stylo brevi apicali. Methye Lake, near Methye Portage, between Buffalo Lake and Pierre au Calumet, Canada. J. M. Macoun, 18/7/1888, No. 20. Griffin Lake, Gold Range, British Columbia, J. M. Macoun, 8/8/1889, No. 2. Type specimens in Geol. Survey Museum, Ottawa, and co-types in my collection.

This must be held a species; at the date of 1890 the American forms of *P. Zizii* were little understood, and even now they require a critical revision, many so named being regarded by Hagström as hybrids, and I partly agree with him.

P. Hagströmi, Ar. Benn., sp. nov.

Caulis simplex 50 cm. longus. Folia submersa lineari-lanceolata sessilia, 7 cm. longa 1.5 cm. lata 11-nervia; natantia lanceolata 3.5 cm. longa 0.7 cm. lata, petiolo 1 cm. longo suffulta, stipulis elongatis pellucidis involucrantibus instructa. Fructus immaturus semi-orbiculatus stylo longiusculo. Chilliwack Valley, British Columbia, between lat. 49° and 49° 10' and long. 121° 25' and 122°. J. M. Macoun, 21/8/1900, No. 26816. Type specimens in Geol. Survey Museum, Ottawa, and co-types in my collection.

In Journ. Bot., xlii (1904), 71, I suggested this as *P. claytonii* × *angustifolius*, but this reference cannot now be held correct and it must be accepted as a new species. Nothing like it has been seen or recorded since 1904. The species is remarkable for the great development of the stipules which are of extreme tenuity, the fibrous nerves standing out with great prominence, and they embrace the whole internode from leaf to leaf on the upper part of the stem. In the whole genus I know of no other species possessing similar stipules. I have named the species in honour of Dr. Hagström, whose Critical Researches on Potamogeton (1916) has done more to elucidate the genus than any work hitherto published.

As regards other species, the nearest approach is *P. azoricus*,

Ar. Benn., a native of the Azores, gathered in 1848 by Mr. Hunt and by Mr. Trelease in 1894.

P. venosus, Ar. Benn., sp. nov.

Caulis simplex 10 cm. longus. Folia ad apicem caulis aggregata lanceolata denticulata 8-10-nervia, nervo medio crasso fulvo, stipulis pellucidis 6 cm. longis. Pedunculus 4-6 longus spicam 5 cm. longam densifloram gereus; perianthi segmenta triangularia; stylus dorsalis brevissimus stigmatibus latissimo munitus. Fructus 3 mm. longus, 2 mm. latus, dorso levis, ventre tricarinatus, carina media paulo alata. In a pool, Umplmzue, Natal, S. Africa, J. M. Wood, 18/4/1884. No. 3015. Type specimen in Kew Herbarium.

This species differs from all known forms of *P. lucens*, Linn., to which it is related, by the thickened, brownish-yellow midribs of the leaves, by the form of the perianth segments, and by the remarkable broad stigma quite overlapping the style.

There are two other new species from South Africa which I hope Dr. Moss will describe, as we agreed to this at Kew.

× *P. Rhodensis*, Ar. Benn., hyb. nov. = *P. amplifolius*, Tuck.
× *pulcher*, Tuck.

Inter *P. amplifolium* et *P. pulchrum* quoad folia submersa ad *amplifolium* spectat quoad natantia *pulchrum* revocat; fructus non visus. Type specimen in Columbia College, U.S.A., and co-types in my collection.

In 1880, T. Morong sent a peculiar *Potamogeton* from Apponang Pond, Rhode Island, U.S.A., and wrote: "A strange form of *P. amplifolius* with oval, coriaceous, submerged leaves which I shall name (perhaps) var. *coriaceus*. It occurs in shallow water with muddy bottom." In the following year (1881) he sent further specimens from the same locality and undoubtedly the same species, but he now regarded the plant not as a form of *amplifolius* but as a state of *pulcher*, produced perhaps by the condition of the water. The plants did not flower or fruit. I think the specimens are best regarded as a hybrid between the two species, and I have named it *P. Rhodensis*.

× *P. perplexus*, Ar. Benn., *hyb. nov.* = *P. natans*, Linn. × *nodosus*, Poir.

Caulis teres, foliis oblongis-ovatis, 9 cm. longis, 4 cm. latis basi haud plicatis, nervis 15-17. Stipulae 9 cm. longae. Pedunculi aequales 6 cm. longae; spica densiflora 3.5 cm. longa. Fructus non visus. Type specimen in Geol. Survey Museum, Ottawa, and co-types in my collection. Chilliwack Valley, British Columbia, between lat. 49° 10' and 49° and long. 121° 25' and 122°, J. M. Macoun, 21/8/1901, No. 26815 *bis*.

In 1902 I wrote to Prof. Macoun saying that at first I considered this a form of *P. americanus*, C. et S. (= *nodosus*, Poir), but afterwards as a hybrid, though I was unable to refer it with certainty. I now think the above reference is correct. The plant differs from *natans* by the want of the leaf-fold at the base and by the leaf shape, and from *nodosus* by the leaf venation and stipules.

NOTES ON CAITHNESS PLANTS. By ARTHUR BENNETT, A.L.S.

(Read 1st May 1924.)

These notes comprise any additions and new localities that have come to my notice since the publication of my former notes in the Transactions of this Society, vol. xxvii, p. 309. New county records are marked with an asterisk.

**Caltha radicans*, Forst.—Scarmclett. Druce, in Bot. Exch. Club Rep. for 1919, p. 636.

**Viola variata*, Jord.—Shores of Loch Wester (1887), Grant sp. Near Wick, Marshall sp. (near this according to Dr. Drabble).

Viola obtusifolia, Jord.—The Glebe, Wick (1879), Dr. Ward sp.

Cerastium triviale, var. *pentandrum*, Syme.—Reiss Links, July 1887, J. Grant.

Geranium sanguineum, Linn.—Coast at Lybster (1920), G. Lillie, sp.

Ulex nanus, Forst.—Another station is recorded for this by Mr. Lillie, who writes: "The place where I got the *nanus* would be at least three miles above Langwell House, and a long way above planted trees and shrubs. It was in a hollow where the earth had been removed to make up the peat road. It would not have been planted as it was so far above the ground. There was a lot of *Calluna vulgaris*, *Galium saxatile*, and *Potentilla Tormentilla*; the ground poor, gravelly, with a slight mixture of peat." *Ulex europaeus*, Linn., is on record for Denmark, but I cannot find that *U. nanus* is known on the Continent farther north than Belgium. On Surrey Commons, *U. europaeus* is sometimes, in severe winters, killed down many inches, but the next year seems to grow better. I have not seen *nanus* so injured.

Vicia sepium, Linn.—Ramsraig, Dunbeath. G. Lillie, sp.

Saxifraga hypnoides, Linn., var. *gemmaipara*.—Below Ramsraig, Dunbeath, July 1919. G. Lillie, sp.

Caucalis Anthriscus, Huds.—Below Ramsraig at Gradh Badh na Muic, July 1919. G. Lillie, sp.

Sonchus asper, var. *pungens*, Bisch.—Wick. Druce, in Bot. Exch. Club Rep. for 1920, p. 133.

Hieracium Sommerfeltii, var. *setosum*, W. R. Linton.—Berriedale.

**Pyrola minor*, Linn.—Reisgill Burn, about one mile above Lybster village. It grows on low ground beside the burn, and in floods the water will surround the place where it grows. June 1922, G. Lillie sp. It grows in E. Sutherland, Grant sp., and specimens are in the British Museum from W. Sutherland. It is recorded for the whole of Finland and Sweden, and occurs in Norway up to 70° 11'. The first specimens sent seemed to point to var. *nummularia*, Laest., ex Hartman in Hand. Skand. Fl., 1879, p. 342, with its head of flowers somewhat like *P. umbellata*, Linn., but later specimens showed it was only the type. Reisgill Burn is a rocky channel made by water through the calcareous flagstones and shelly boulder clay. It is botanically one of the best localities in the county. Mr. Crampton enumerates some fifty characteristic species that grow by it.

**Euphrasia nemorosa*, Pers., var. *ciliata*, Drabble.—Duncansbay Head. Druce, in Bot. Exch. Club Rep. for 1922, p. 740. *E. Rostkoviana*, Hayne.—Reay. Druce, *l.c.*, p. 740.

Primula scotica, Hook.—I do not find the Caithness specimens differ in the relative length of the calyx and capsule as the Orkney specimens do. Hooker, in Student's Flora, says, "capsule shortly oblong, scarcely exceeding the calyx." But in specimens from Dennett Links (1880) the capsules are half as long again as the calyx.

Mentha alopecuroides, Hull.—John o' Groat's. Druce, in Bot. Exch. Club Rep. for 1919, p. 672.

Betula nana, Linn.—Forsinard, Caithness, 1921. J. N. Bedall-Smith ex Little, in Bot. Exch. Club Rep. for 1922, p. 747. But Forsinard is in Sutherland, the nearest elevation in Caithness being Cnocnan Gall, 902 feet.

Salix alba, Linn.—Traill, in Ann. Scot. Nat. Hist., 1906, p. 181.

**Alisma Plantago*, Linn.—Wick River, Sinclair Manson, 1907, and near Wick, R. Bain, 1905.

Habenaria albida, R. Br.—Near Swiney, Lybster. Miss M. Little.

Potamogeton heterophyllus, Schreb.—Wick watercourse, J. Grant sp. Loch Yarehouse, J. Grant sp., and Loch Stemster, G. Lillie sp.

P. nitens, Weber.—Loch Winless, Hanbury sp. Mill Dam, Thurso, Shoolbred sp.

P. praelongus, Linn.—Loch Stemster, Yarrow Loch, water-course near Wick River, J. Grant sp.

P. alpinus, Balb.—Loch Stemster, G. Lillie. Wick River and Loch Yarehouse, J. Grant sp.

P. panormitanus, Biv. Bern.—Halkirk, Dr. Davidson sp. Loch Scarmclell, Lillie sp.

P. pectinatus, Linn., var. *diffusus*, Hagst.—Near Wick, J. Grant sp.

P. filiformis, Pers.—Wick River, f. *major*, Tis., and f. *vulgaris*, Hagst. Pulteneytown Water, J. Grant sp. Ditch by the Old Man of Wick, Kidston sp.

Juncus alpinus, Vill.—With *Saxifraga Hirculus* between Lybster and Loch Rhuard, G. Lillie sp.

When Mr. J. F. Grant and I wrote Contributions towards a Flora of Caithness (Scottish Naturalist, 1888), the number of Caithness species and varieties on record was about 563 ; at present about 726 are recorded.

THE STEM STRUCTURE OF *SARGENTODOXA CUNEATA*, REHD.
ET WILS. By ELIZABETH M. HENDERSON, M.A., B.Sc.

(Read 21st February 1924.)

Sargentodoxa cuneata is a twining plant, belonging to the family Lardizabalaceae, a small family of lianes closely related to Berberidaceae. A native of Central China and Indo-China, the plant is found growing at altitudes from 1800 to 4000 feet. Its relationships seem to be with *Holboellia*, to which genus it was at first referred, but later it was given distinct generic rank under the name *Sargentodoxa*. The genus is defined by Rehder and Wilson (1913) in *Plantae Wilsonianae*, vol. i, p. 350. These authors point out that its establishment is based on the characters of the fruit. The number of ovules in each carpel is reduced to one, and the number of carpels is multiplied as compared with typical members of the family.

Internodal Anatomy.—In a fully developed internode the primary stem measures 4 mm. in diameter. Externally there is a well-defined epidermis composed of cells elongated at right angles to the axis. Within, there are some five rows of thin-walled cortical cells, which are considerably compressed. This relatively narrow cortex is defined internally by a well-marked endodermis, the walls of whose cells are suberised; these endodermal cells are more radially elongated than the cortical cells. Within the endodermis is a broad, unbroken band of lignified pericyclic fibres extending to about fifteen layers, as seen in transverse section. On the inner side of this ring of fibres there lies a narrow zone of thin-walled pericyclic tissue from which the cork cambium arises. The periderm is thus deep-seated in origin, and makes its appearance soon after the complete differentiation of the pericyclic fibres, when the stem is from four to five months old.

The vascular strands traced through an internode are twelve in number, and as seen in transverse section dispose themselves in two rings, the inner of which comprises four large prominent strands. In the outer ring of smaller strands, two occupy a lateral position, while three occur medianly,

occupying a position outside of, but between the two pairs of large strands (Figure, Diagram A).

Associated with the vascular strands are large tannin-containing sacs, formed of cells which are about twice as long as broad. They appear early and can be readily recognised in the fifth internode.

Successive internodes of a shoot of one year's growth were examined in turn, in order to trace the differentiation of the tissues described above, and in doing this certain variations in starch content and distribution were observed which seem worth recording.

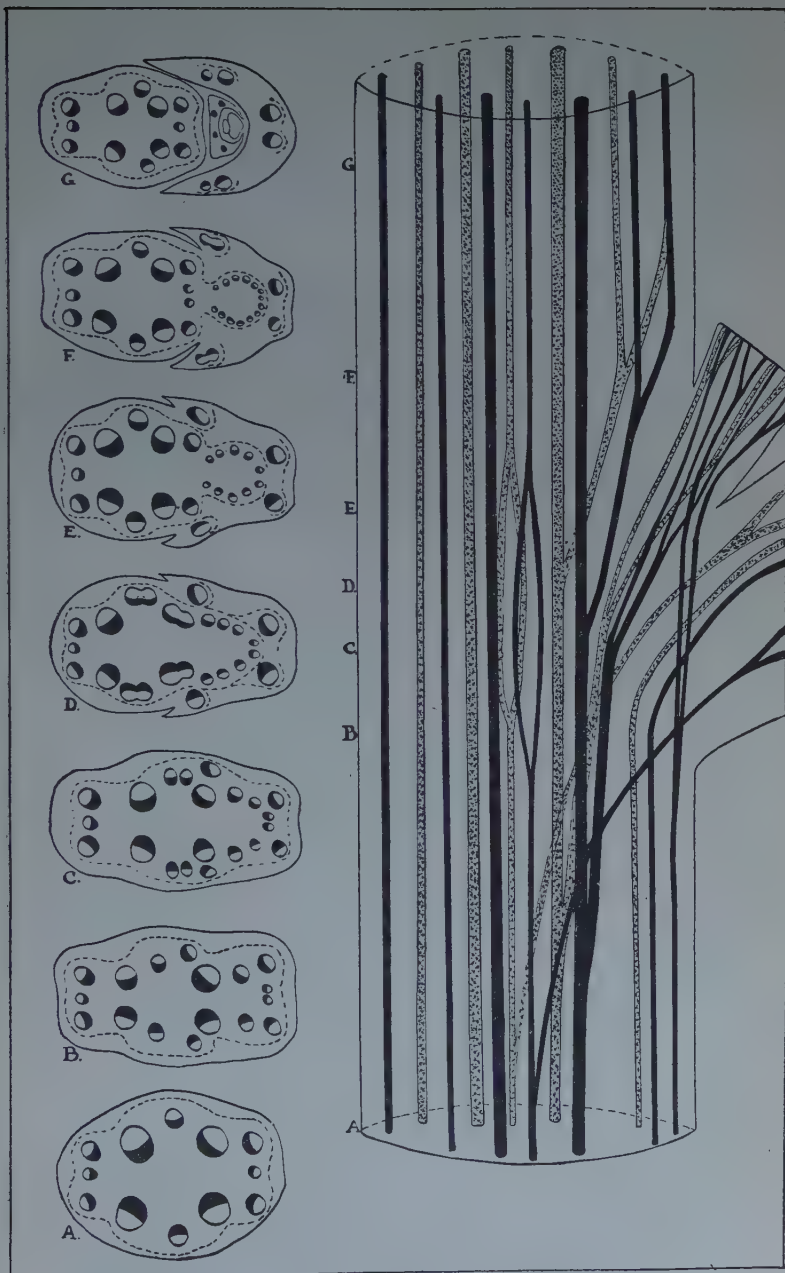
In the young internodes behind the meristematic apex, where the conducting strands are undergoing differentiation, the amount of starch is small, and is fairly uniformly distributed throughout cortex and pith.

In the 7th, 8th, and 9th internodes there is abundant starch in the cortex, and less in the pith, while in the 10th internode there is none, or very little in the pith. Here, however, the endodermis becomes clearly defined as a starch sheath, its cells being rich in starch, and throughout the 11th and 12th internodes the starch is confined to the endodermis, there being none in the pith or cortex.

In the 12th internode lignification of the pericycle begins and is well advanced by the 13th internode. With increase of lignification of the pericyclic fibres the amount of starch in the endodermis decreases, until, in the 15th internode, starch is almost confined to tissues within the sclerotic ring, occurring in the medullary rays and pith. At this stage the endodermal cells are distinctly suberised and the cork cambium can be detected in the parenchyma just within the pericyclic fibres.

In the 20th and older internodes there is abundant starch in the medullary rays and in the pith, the endodermis is suberised and cork formation has proceeded to the extent of two or three rows of cells.

The physiological significance of the conditions just described requires an investigation which is beyond the scope of the present inquiry. The observed facts seem to agree, however, with those mentioned by Haberlandt (1914) in his treatment of the statocysts of stems and leaves, and while the peculiar limitations of starch grains to the cells of the endo-



Vascular system in stem of *Sargentodoxa cuneata*.

dermis in the actively elongating internodes of the stem may have some relation to the execution of geotropic curvatures, it seems clear that a more detailed study of the chemical nature of the cell-wall in the endodermal layer is required before the question can be fully discussed.

Nodal Anatomy.—The leaves alternate in two rows, and at each node only the strands of one side of the stem are affected by the insertion of the leaf.

Tracing the strands from the typical internode down through the node below, the first change which occurs is the forking of the central of the three median bundles, and each of the shanks inserts itself on one of the lateral strands of this median group (F). The two thus formed unite with the large strands on the side next the leaf. These two large strands fork below the node and give rise to numerous branches which pass out to supply the axillary bud, while their main portions continue downwards (C).

The leaf trace consists of four strands, of which the outermost two unite with the small lateral strands from the internode above, while the other two pass directly downwards as the laterals of the median group of these small strands (B). Finally, there is the median of these three strands, which is formed by the union of branches coming directly from the axillary bud. Thus the original condition of the internode is again reached (A).

This interesting anatomical feature, of one strand being related to the axillary bud, was discovered in hand sections and checked by tracing the vascular system in a macerated stem, and with greater precision by a study of the growing point. In serial sections made through the apex, it was found that this small median strand appears in the axis only after the formation of the first axillary bud, *i.e.* in the axil of the fifth leaf.

Thus ten of the twelve strands of the stem are referable to leaf traces, while the remaining two are associated with the development of the bud in the leaf axil.

It is of interest to note that the starch sheath becomes broken at the node where the leaf trace departs, each strand being subtended by a starch crescent.

This condition is mentioned by Haberlandt as occurring in nodal pulvini which are geotropically sensitive. The endo-

dermis encloses the strands of the bud as well as those of the main axis, until the bud becomes separate, when the endodermis of the axis is again completed.

Secondary Growth in Thickness.—With secondary growth in thickness considerable twisting of the stem is obvious from the presence of spirally arranged longitudinal furrows. These furrows, six in number, are seen in transverse section to arise from a splitting of the cortex and fibres, the split generally extending as far as the cork.

The formation of these furrows is foreshadowed in the young stem by the occurrence of V-shaped patches of thin-walled cells penetrating into the pericyclic fibres, and it is along these lines of weakness that splitting occurs.

The original plan of four large main bundles can still be recognised in a two-year-old stem.

Comparison with other Lardizabalaceae.—The other members of the family examined for comparison were:—*Holboellia latifolia*, *H. angustifolia*, *Lardizabala bitermata*, *Akebia quinata*, and *Decaïsnea Fargesii*, and though they all show remarkable similarity amongst themselves, they exhibit marked differences from *Sargentodoxa*.

Considered generally, they all possess conducting strands of approximately equal size arranged in one ring and a discontinuous band of pericyclic fibres, the fibres occurring in patches on the external margins of the phloem, extending in some cases, e.g. *Holboellia latifolia*, *H. angustifolia*, *Akebia quinata*, and *Lardizabala bitermata*, round the lateral margins of the phloem as far as the level of the cambium. In *Decaïsnea* this interfascicular sclerenchyma is least marked.

External to this lignified pericycle is a layer of thin-walled cells containing small quantities of starch and therefore definitely recognisable as a starch sheath.

The cortical cells are large and thin-walled, with intercellular spaces, and not compressed at all; the cortex varies in width from five rows in *Akebia quinata* to twelve rows in *Holboellia angustifolia*.

The pith in *Sargentodoxa* and in *Decaïsnea* is thin-walled and parenchymatous, but in *Holboellia angustifolia* and *Akebia quinata* it is thick-walled at the periphery, while in *Holboellia latifolia* and *Lardizabala bitermata* it is thick-walled throughout.

The cork cambium in all cases is sub-epidermal in origin.

Thus the chief points of difference between these members of the family and *Sargentodoxa* are:—(1) equal size and regular arrangement of the vascular strands; (2) the discontinuous sclerenchymatous tissue; (3) the thickened pith, and (4) the superficial origin of the cork cambium.

Harvey-Gibson and Horsman (1919), in their paper on "The Anatomy of the Stem of the Berberidaceae," state that no endodermis is distinguishable among the Lardizabalaceae save in *Akebia*, but the presence of starch in the layer external to the pericyclic fibres in all those stems examined seems to indicate that the endodermis is a fairly general feature of the family.

Réaumbourg (1906), working on the internodal anatomy of the genus *Holboellia*, which at that time included *Sargentodoxa cuneata*, describes for that species a patch of sclerenchymatous cells in the centre of the pith, but this has not been found in any of the specimens examined.

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THE LEAF STRUCTURE OF *BEGONIA FUCHSIODES*, HOOK.

By M. M. B. KNAGG, B.Sc.

(Read 21st February 1924.)

Begonia fuchsioides is a native of the Ocaña Mountains in New Grenada, where it was discovered in 1846 and subsequently introduced into this country. It is a shrubby plant, from 2 to 4 feet high, with inflorescences of pink, fuchsia-like flowers, and small green leaves. There is a certain degree

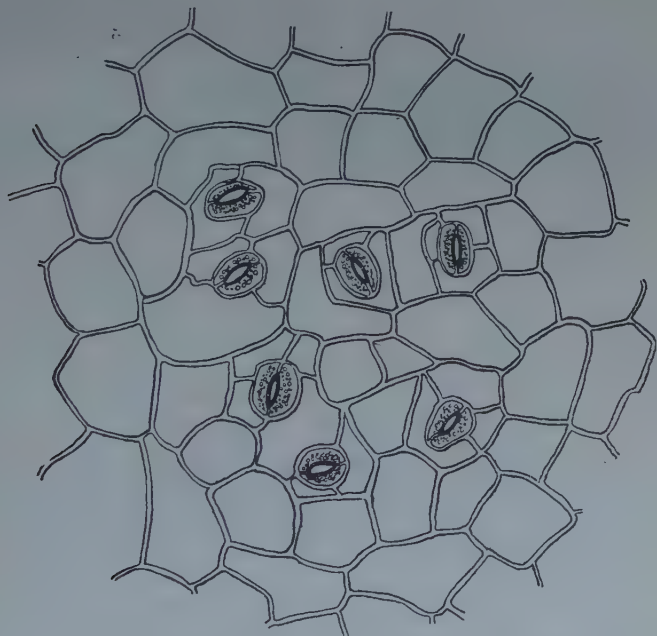


FIG. 1.—Portion of lower epidermis of leaf showing a single stomatal area, $\times 112$.

of succulence in the latter, and also in the globular flower-buds, which may be considered as an environmental adaptation to the hot climate of Mexico. It is said that the plant, on account of its succulence, is commonly eaten by mule-drivers to allay their thirst.

The leaves are numerous, alternate in arrangement, and comparatively small in size, being, on an average, not more

than an inch long and half an inch broad. They are glabrous, and oblong-ovate in shape with serrated margins. The adaxial surface is rich dark green in colour, whilst the abaxial surface is silvery green with many lighter-coloured areas scattered over the surface. The stomata are entirely confined to these areas on the under surface, and there are none at all in the upper epidermis, so that in comparison with the size of the leaf stomata are relatively few in number. There may

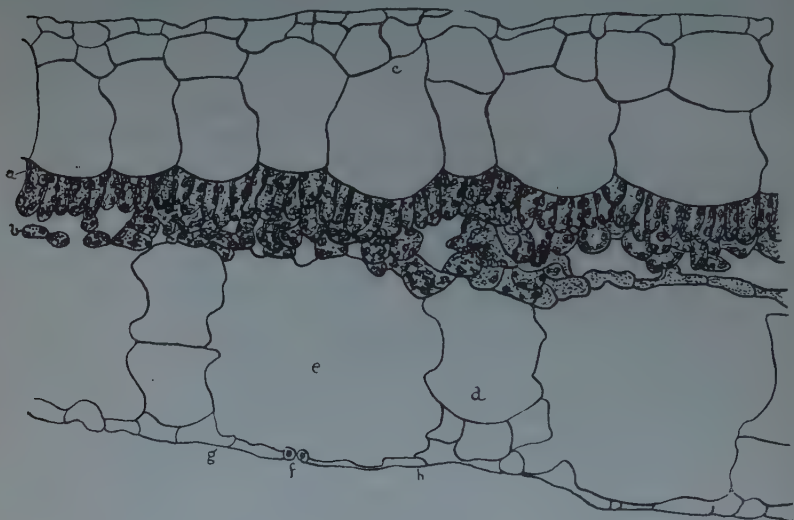


FIG. 2.—Part of a transverse section through leaf; *a*, palisade parenchyma; *b*, spongy parenchyma; *c*, water-cells on upper side of leaf; *d*, water cells on lower side of leaf; *e*, air-space or "tunnel" leading from lower epidermis to mesophyll; *f*, stoma; *g-h* represents the extent of a single stomatal area, $\times 100$.

be from 3 or 4 to a dozen stomata within a single area. Their distribution is indicated in fig. 1, which represents a portion of the lower epidermis in surface view. This restriction of stomata to certain areas of the epidermis is characteristic of the Begoniaceae as a whole. The reason for this construction, in this case, is seen when the internal anatomy of the leaf is examined.

A portion of the transverse section of the leaf is shown in fig. 2. It will be seen that the chlorophyllous tissue is concentrated to form a narrow band in the centre of the leaf, and is surrounded by an envelope of water-cells which are bounded

by the upper and lower epidermis. This chlorophyll tissue consists of a single layer of palisade parenchyma (*a*) forming its upper half, with spongy parenchyma (*b*) below. The cells of the spongy parenchyma contain fewer chloroplasts than do those composing the palisade parenchyma, and the air-spaces are small in size and relatively few in number. Ramifying throughout the mesophyll is a network of small veins. These are branches of the midrib and are normal in structure.

The water-tissue above and below the mesophyll consists of thin-walled cells which vary somewhat in size, and are more or less hexagonal in form, while their ventral walls show the wavy outline characteristic of water-cells in general. The cells above the mesophyll (*c*) form a continuous layer, but those below (*d*) are arranged in the form of a network with large air-spaces, one of which is shown at *e*. These air-spaces form tunnels by means of which certain areas of the epidermis are brought into direct communication with the mesophyll without any intervening water-tissue. The areas referred to contain the stomata, and one of these is shown in section at *f*, the area to which it belongs extending from *g* to *h*.

The epidermis is essentially similar on both surfaces of the leaf, apart from the limitation of the stomata to the under surface, and no cuticle is present in either case. The absence of cuticle from a leaf which possesses a water-tissue contrasts strongly with the conditions found in succulent leaves of xerophytes where usually a cuticle is present, protecting the water-tissue from excessive loss of water.

The intensity of the green colour of the leaf is striking when it is remembered that the water-jacket intervenes between the mesophyll and the epidermis. The absence of cuticle may also partly account for the depth of colour, and may equalise any effect of the water-cells inhibiting the passage of light to the chloroplasts. Photosynthesis is therefore not impaired by the presence of the water-jacket; in fact the uninterrupted activity of the chlorophyll tissue is ensured by the presence of these water-cells, whose cooling effect counteracts the excessive insolation inseparable from the Mexican climate.

In conclusion, I wish to express my thanks to Professor Wright Smith, who provided facilities for carrying out this work.

"HARD SEEDS" AND BROKEN SEEDLINGS IN RED CLOVER.
By ALEXANDER NELSON, B.Sc., N.D.A.

(Read 20th March 1924.)

While testing the germination of the seed of most cultivated species of Leguminosae there commonly occur seeds which do not absorb moisture, and in consequence these fail to swell up and germinate within the period of the test. These are known as "hard seeds." This inability to absorb moisture is due to some peculiarity of the seed-coat, and in order to reduce the number of "hard seeds" in a consignment it is the usual practice in commerce to pass it through certain machines which scratch or abrade the surface of the seeds, thus permitting water to be taken up. It is believed that in time and in the soil untreated "hard seeds" will germinate and produce a plant. Many clovers, however, particularly red, occupy the land for a relatively short period, and so the hard type of seed may not be allowed enough time to germinate and assist in producing a crop. The germinating percentage of any given sample, for the purposes of a declaration under the seed-testing regulations, is reduced by the percentage of "hard seeds" which occur. The percentage of germinating seeds in Clover, Trefoil, etc., is usually further reduced by the occurrence of what are called broken seedlings. A broken seedling is one which during the germination test breaks into two or more portions, each of which is incapable of producing a plant: the break is usually in the region of the hypocotyl. A high percentage of either of these "impurities" lowers the market value of a sample considerably. It was noticed in certain cases in the course of the ordinary routine testing of seeds that the machining of a sample of red clover, though it had reduced the number of "hard seeds," had not increased the percentage of seeds germinating, simply because the percentage of broken seedlings had been considerably increased. In the case of samples of Alsike or white clover the "hard seeds" were almost completely eliminated with no increase of broken seedlings. Critical tests of red clover seed were then commenced and the results noted, these being shown in Table I.

TABLE I.

Consign- ment number.	Absolute weight, 1000 seeds.	Treatment.	Per- centage of germinat- ing seeds.	Per- centage of hard seeds.	Per- centage of broken seedlings.	Per- centage of dead seeds.
404	2.22 grams	Unmachined	90.25	7.75	2.0	0.0
"	" "	Over A	86.75	7.75	5.0	0.5
"	" "	Over B	82.25	4.25	12.75	0.75
420	2.15 grams	Unmachined	82.5	13.25	3.5	0.75
"	" "	Over A	88.75	7.25	4.0	0.0
"	" "	Over B	86.0	4.0	9.25	0.75
656	2.15 grams	Unmachined	90.5	7.0	1.75	0.75
"	" "	Over A	87.5	5.0	6.75	0.75
"	" "	Over B	85.75	3.75	10.0	0.5
545	1.99 grams	Unmachined	91.5	8.25	0.25	0.0
"	" "	Over A	92.5	5.0	1.25	1.25
"	" "	Over B	93.75	4.25	1.75	0.25

Four consignments of unmachined seed were selected, and each divided into three portions. The first portion of each consignment was left unmachined; the second portion was passed through a machine designated A; while the third was passed through machine B. Thus were obtained twelve samples in all, three from each of the four consignments selected. The machines A and B are of the latest type and in general use by the seed trade. The action of machine B is more drastic than that of A.

The four consignments included two distinct types: those numbered 404, 420, and 656 were large, bright, and of Chilian origin, while the fourth (545) was a smaller-seeded type of English origin. As a fairly accurate guide to the relative sizes of the seed the absolute weight is given, this being the average weight of at least five lots each of 1000 seeds.

The twelve samples were then tested for germination in the usual way—two pads of blotting paper each carrying 200 seeds and marked X and Y respectively, moistened and put in a germinator run steadily at 22° C. The complete results after ten days are given in the table. All pads were under exactly the same conditions during the whole course of the test. A duplicate germination test was carried out some time later, which fully confirmed the figures given. The control

samples ordinarily used in the routine working of the station behaved in a normal manner during the period of these tests.

CONCLUSIONS.—From these tests it would appear that the use of abrasive machinery on large, well-developed red clover seed gives negative results. The “hard seed” percentage is undoubtedly reduced, but the percentage of broken seedlings is raised by an equal or even greater amount, leaving the declarable “germinating percentage,” which it was desired to raise, as low as or lower than before treatment.

In the case of a smaller type of seed, such as sample 545 in these tests, machining does reduce the number of “hard seeds” without materially increasing the number of broken seedlings.

It is suggested that the increase in the number of broken seedlings in large red clover seed noted after the use of abrasive machinery may be due either to the thinning down of the seed coat in certain regions, thus upsetting the normal action of the stresses which occur in the germinating seed, or to actual damage to the embryo. It is also suggested that determination of the absolute weight of a sample provides a guide to seed merchants as to whether it will be profitable to subject any consignment to an abrading process.

The writer desires to acknowledge the courtesy of Messrs. David Bell, Ltd., in whose station these tests were made, for permission to publish the results.

VEGETATIVE PROPAGATION OF ORNITHOGALUM AND DRIMIA.

By R. J. D. GRAHAM and L. B. STEWART.

(Read 12th October 1923 and 15th May 1924.)

ORNITHOGALUM.

Vegetative reproduction in species of *Ornithogalum* (*Arabicum*, *caudatum*, *Eckloni*, *longibracteatum*) takes place by axillary buds produced in the axils of the scale leaves and also by bulbils on the abaxial surface of the swollen cylindrical leaf bases which constitute the tunicate bulb. On the abaxial surface of the outermost leaf base in line with the suture of the leaf margins, bulbils are found at varying levels. On dissecting a bulb, bulbils are disclosed at successively lower levels till on the sixth or seventh leaf base they are visible immediately above the insertion of the leaf on the stem. The upward movement of the bulbil is due to intercalary meristems, a lower one at the insertion of the leaf and a second on the leaf base immediately below the bulbil. The bulbil is thus raised in response to the pressure of the superimposed leaf bases, while vascular connection is maintained between bulbil and stem. Normally the movement of the bulbil ceased on removing the superposed leaf base.

Bulbs cut longitudinally in half were placed on a shelf exposed to daylight in a dry bulb pit with a night temperature of 60° F. until the mucilage from the injured surface was dry. Leaf bases were then removed and laid on sand which was watered once in ten days. During the third and fourth weeks buds developed freely on the adaxial side of both halves of the isolated leaf bases. In contrast to the normal bulbils, which develop singly or in small numbers, these induced buds arose copiously. Only in one case has the development of a single induced bud been noted, and this was from the intercalary meristem at the apex of the vascular tract, from which the bulbil had been accidentally removed. This was the only record of induced bud formation on the abaxial leaf surface.

The structure of bulbil and induced bud is similar. The first leaf was juvenile, consisting only of a swollen cylindrical leaf base, the lamina appearing on the second and subsequent

leaves in the induced bud, but not till the fourth leaf of the bulbil. The bulbils due to pressure are flattened tangentially to the leaf base bearing them, while the induced buds, owing to absence of pressure, were symmetrical.

Microscopic examination of the detached leaf base disclosed at the time of induced bud formation a line of parenchyma cells which had become meristematic. Towards the injured surface the divisions rapidly became suberised, cutting off the injured portion. Suberised cells were also seen on the abaxial surface extending for a short distance above the point of injury. On the adaxial surface the divisions rapidly organised into a limiting cutinised layer enclosing starchy parenchyma in whose centre spiral vascular elements soon differentiated.

The first roots developed from the detached bulbils, as also from the induced buds, were contractile.

This development of induced buds is in sharp contrast to the phenomena recorded (Trans. Bot. Soc. Edin., xxviii (1923), 183) for *Haemanthus hirsutus*, where bud formation was induced in the hypodermal layers of the detached leaf bases. Excision of the callus with attached buds in *Ornithogalum* resulted in desiccation of the remainder of the leaf base without further bud formation, similar treatment in *Haemanthus* inducing fresh bud formation at a point above the injury.

DRIMIA CILIARIS, JACQ.

The bulbs of *Drimia ciliaris* in being scaly bulbs differ from those whose vegetative propagation has already been described. The youngest leaves consist of a swollen basal portion which persists and a relatively short-lived lamina. The outer bulb scales show a distinct stalk portion with a rounded, swollen head. On dissecting the bulb a gradual change in contour of the scales is visible, owing to the absence of the stalk portion in the younger scale. This elevation of the region of maximum storage in the oldest scale permits a relatively compact bulb to be constructed with the maximum of reserve material. The reserve is mainly a reducing sugar, and cells with anthocyanin give a purple colour to the scale. Special cells with Calcium Oxalate raphides probably account for the irritant properties associated with this plant (Walsh, 1910).

Scales from bulbs treated as described in *Haemanthus* and

Ornithogalum, 4-5 weeks after removal indicated cell activity on the adaxial surface by the appearance of white patches free from anthocyanin. Meristematic activity commenced in the hypodermal parenchyma of the scale leaf and the products quickly oriented themselves into the leaf papillae of an induced bud. Meristematic activity was also seen in a line of parenchyma cells at the stalk of the scale. Towards the injury the products rapidly became suberised. Suberised cells were also visible on both surfaces of the stalk above the point of injury. The epidermis on the abaxial surface was cuticularised. On the adaxial surface above the injury the higher products arranged themselves into an induced bud. The induced buds in both positions soon differentiated vascular elements and became connected with the vascular supply of the scale.

The first leaf consisted of a white swollen basal portion whose colour, however, soon changed to a purple as a result of the accumulation of reducing sugar. A green lamina may be developed as early as the second leaf, but more usually was found on the fourth leaf. The first roots were contractile.

This development shows a connecting stage between that of *Haemanthus* and of *Ornithogalum*. Bud formation can be induced either in the parenchyma cells of the scale or in the callus formed as the result of injury. All attempts to induce bud formation on the abaxial surface have failed. This may be associated with the absence of vascular tissue from the abaxial surface.

REFERENCE.

WALSH, D., 1910 : British Medical Journal, vol. ii.

SOME MOSS RECORDS FOR SELKIRK. By J. R. SIMPSON.

(Read 15th May 1924.)

The following moss records, with notes relating to their distribution and habitats, have been compiled since October 1920. The district most carefully examined comprises the estates of Bowhill, Philiphaugh, and The Haining.

During 1921 an excursion was made to Henderland Burn, which empties itself into the Meggat near St. Mary's Loch, and the mosses found on that occasion are included in the list, with a few others collected in Yarrow near Yarrowfeus.

The moss flora of the district mainly studied is very rich, and many of the species observed from time to time in the fertile condition are amongst those in which the sporogonia are usually regarded as rare. The most notable of these is perhaps *Leptodontium flexifolium*, Hampe, which was first found fruiting abundantly on Newark Hill, and has since been found on the Peat Law and the Three Brethren. Mr. Sherrin, in a note to the writer, says that he has never before seen this species in fruit.

In 1917 the late Wm. Evans, F.R.S.E., read a paper before this Society giving a list of many additions to the Selkirkshire record. In his paper Evans (p. 138) says that the "Selkirk list must be far from complete." The present list includes many new localities for species recorded by him, and these are distinguished by the letter E. In addition, the list contains 39 species not previously recorded for the county, and these are marked with an asterisk. Nine of these occurred on the soil of the newly drained Bowhill Loch. It is probable that several of the *Sphagna* are also new records for the county.

The majority of the records have been authenticated by Mr. J. R. Lee, and a large number by Mr. W. R. Sherrin. To these gentlemen, and also to Messrs. J. A. Wheldon, D. A. Jones, F. Rilstone, and R. H. Corstorphine, my thanks are due for their kind assistance.

The nomenclature is uniform with that of the Census Catalogue, except in the case of the *Sphagna*, which are

arranged in accordance with Wheldon's Synopsis of European Sphagna.

Sphagnum Warnstorffii, Russ.—Marsh, Linglie Hill.

S. acutifolium, Ehrh.—Marsh, valley, Foulshiels Hill, Three Brethren, and Peat Law.

A barren form from Peat Law, Mr. Sherrin says, is "a very curious plant, very interesting, and very difficult, not quite typical." Another barren form from marshland in a young fir wood at Bowhill Mr. Sherrin identifies as this species, but with "abnormal stem-leaves."

S. quinquefarium, W.—Marshland, young fir wood, Bowhill. Barren.

S. quinquefarium, W., var. *pallens*, W., f. *orthocladium*, W.—In same locality as the last.

S. quinquefarium, W., var. *roseum*, W., c. *heterocladium*, W.—Locality as above.

S. plumulosum, Roll.—Marsh, Peat Law.

S. plumulosum, W., var. *versicolor*, W., a. *validum*, W.—Locality as above.

S. plumulosum, W., var. *versicolor*, W., f. *tenellum*, W.—Locality as above. Barren.

S. squarrosus, Pers., var. *spectabile*, Russ. d. *robustum*, W.—Marsh, valley, Foulshiels Hill, Three Brethren, and Peat Law.

W. R. S. says: "The *Spag. squarrosus* Russ. was the finest of its kind I have ever seen."

S. recurvum, P. de Beauv., var. *majus*, Angstr. d. *sphaerocephalum*, W.—Marshland, young fir wood, Bowhill. Barren.

S. cuspidatum, Ehrh., var. *submersum*, Schimp.—Bog, submerged, Mountbenger Law, Yarrow. Barren.

S. cuspidatum, Ehrh., var. *plumosum*, Schimp.—Bog, submerged, Fastheugh Hill. Barren.

S. cymbifolium, Ehrh.—Marsh, Linglie Hill. Barren.

S. cymbifolium, Ehrh., var. *pallescens*, W.—Marsh, valley, Foulshiels Hill, Three Brethren, and Peat Law.

S. cymbifolium, Ehrh., near var. *flavescens*, L.—Marshland, young fir wood, Bowhill. Barren.

S. cymbifolium, Ehrh., a striking form with an abundance of fruit.—Marsh, valley, Foulshiels Hill, Three Brethren, and Peat Law.

Catherinea undulata, Web. & Mohr.—Bowhill woods, and common throughout the district.

Polytrichum aloides, Hedw.—On clayey soil, The Priory grounds, Philiphaugh woods, and roadside near Colin's Bridge, Ettrick.

P. urnigerum, L.—On rocks, burnside nr. Corbie Linn, and Wark Burn fir woods.

P. piliferum, Schreb.—On sods, top of old wall, Selkirk Hill summit. (E.)

P. juniperinum, Willd.—Common on Linglie Hill, Howden Haugh, etc. (E.) On Linglie Hill the red fruit stems and straw-coloured calyptrae was a colour effect worth going some distance to see. The male inflorescence, which is generally abundant, is a rich purplish red.

**P. strictum*, Banks.—Bog, Linglie Hill. A very distinctive and beautiful species of *Polytrichum* in the field. Growing with *Sphagnum* and fruiting freely.

P. gracile, Dicks.—The Haining woods. (E.)

P. commune, L.—Bowhill woods, heaths, etc., common. (E.)

P. formosum, Hedw.—Bowhill woods, and common in wooded areas.

**Pleuridium subulatum*, Rabenh.—Roadside nr. Corbie Linn. A lovely little moss in the field, fruiting abundantly.

**Swartzia montana*, Lindb.—Old wall base, stone and lime, nr. The Haining west lodge, town outskirts.

Ceratodon purpureus, Brid.—Wood clearings, Philiphaugh, Bowhill, The Haining, by roadsides, on heaths, walls, etc. One of the commonest mosses in the district.

Dicranella heteromalla, Schp.—The woods of Bowhill, Philiphaugh, and The Haining, on heaths, etc.; well distributed. (E.)

**D. varia*, Schp.—On damp, crumbling shale in Thornbush Quarry, Selkirk Hill.

D. squarrosa, Schp.—Slopes of Fastheugh Hill, and on heaths fairly common. Generally in damp situations, burn-sides, drains, and flushes. Regularly barren. (E.)

**Dicranoweisia cirrata*, Lindb.—A common moss on red sandstone wall coping nr. Selkirk.

Dicranum scoparium, Hedw.—Common in woods and on heaths.

Leucobryum glaucum, Schp.—Found several times on heathlands, principally on Linglie Hill, Peat Law, and Three Brethren, but not common. Always barren. (E.)

Fissidens bryoides, Hedw.—Mungo Park's Moss. Found within a stone's-throw of the ruins of Foulshiels, the birthplace of the famous traveller. This dainty moss is generally distributed around Selkirk, on shady banks, under overhanging tufts, at tree roots, etc. (E.)

F. adiantoides, Hedw.—In damp situations, nr. Peat Law base, on Linglie Hill, side of Henderland Burn, etc.

F. taxifolius, Hedw.—On damp, crumbling shale, burnside nr. Corbie Linn, on clay at side of a spring, mouth of Howden Burn.

Grimmia apocarpa, Hedw.—On walls, stones, and rocks. Common.

G. apocarpa, var. *rivularis*, Web. & Mohr.—Wet rocks, Yarrowside, nr. Newark Castle. Often found in similar situations. (E.)

G. pulvinata, Smith.—On walls, stones, and rocks, Philiphaugh, The Haining, Bowhill, and Selkirk town. One of the commonest wall mosses in the district, a distinct feature on nearly every wall. (E.)

**G. trichophylla*, Grev.—Red sandstone wall coping nr. Selkirk. Barren.

**G. dicipens*, Lindb.—Situation as above. In fruit but scarce.

Rhacomitrium aciculare, Brid.—On boulders, Henderland Burn. On damp crumbling shale, burnside nr. Corbie Linn. Not uncommon.

R. fasciculare, Brid.—Red sandstone wall coping nr. Selkirk. (E.)

R. heterostichum, Brid.—On boulders, Henderland Burn, and on red sandstone wall coping nr. Selkirk. Common. (E.)

R. canescens, Brid.—On water-washed sand, side of river Ettrick, abundant. On wall top, district stone, roadside nr. Foulshiels, etc. (E.)

R. canescens, var. *ericoides*, B. & S.—On water-washed sand, side of river Ettrick, nr. Selkirk Bridge.

**Ptychomitrium polyphyllum*, Förn.—On walls, not uncommon in the district.

Hedwigia ciliata, Ehrh.—Old dry-stone wall in Howden Glen, and on red sandstone wall coping nr. Selkirk. (E.)

Pottia truncatula, Lindb.—On clay in stubble field nr. South Common farm. (E.)

Tortula muralis, Hedw.—Common on walls in Selkirk, The Haining, Bowhill, and Philiphaugh. (E.)

T. subulata, Hedw.—On roadside clay nr. Howden, and on walls nr. Selkirk. On hawthorn tree trunk, Haining Rig. *Note*.—"A stunted form, due doubtless to the habitat."—J. R. L. (E.)

T. laevipila, Schwaeg.—On ash tree trunk nr. Oakwood Mill. (E.)

**T. intermedia*, Berk.—Wall cranny nr. the Pot Loch.

T. ruralis, Ehrh.—Old moss-covered wall in Howden Glen, and on walls not uncommon. (E.)

Barbula rubella, Mitt.—Stone and lime wall, roadside nr. Philiphaugh, and well represented on walls generally. (E.)

**B. Hornschuchiana*, Schultz.—Side of meadow path nr. Howden Moat. Barren.

B. convoluta, Hedw.—On roadside clay nr. Howden farm. Barren. (E.)

B. unguiculata, Hedw.—On walls nr. Corbie Linn and General's Bridge not uncommon, also on roadside clay nr. Howden. (E.)

**Leptodontium flexifolium*, Hampe.—Slopes of Foulshiels Hill, Newark Hill, Peat Law, Three Brethren, etc. Found in fruit several times.

This species appears to favour areas where the common ling, *Calluna vulgaris*, has been recently burned. In nearly every such clearing in the district it is to be seen in lovely green patches, contrasting pleasingly with the black surroundings.

Weisia viridula, Hedw.—A common little moss, on rocks, dry-stone walls, on clay, on alder tree trunk, roadsides, etc.

W. rupestris, C. M.—On rocks, side of Henderland Burn. Abundant there and barren.

Encalypta streptocarpa, Hedw.—On wall lime nr. Harehead, nr. Mauldsheugh, and nr. General's Bridge, etc. Fairly common and always barren. (E.)

**Ulota crispa*, Brid.—On branches of hawthorn and hazel, and on mountain ash trunk, etc.

**Orthotrichum anomalum*, var. *saxatile*, Milde.—Wall top, on lime, Philiphaugh Nursery, and on wall nr. Selkirk High School.

O. Lyellii, Hook & Tayl.—Ash tree trunk, The Haining woods, fruiting freely. (E.)

O. affine, Schrad.—Wall lime nr. Philiphaugh saw-mill. Well established there in little cushions; also on walls around Selkirk. (E.)

O. stramineum, Hornsch.—The Haining woods, on several beech tree trunks. (E.)

**Physcomitrium pyriforme*, Brid.—On wet clay, side of small pond nr. Howden farm.

Funaria ericetorum, Dixon.—On clay, side of drain, Foulshiels Hill; also on clay in the valley between Foulshiels Hill and Peat Law.

**F. hygrometrica*, Sibth.—Bowhill wood clearings, etc. A very common moss, fruit generally abundant. Wherever trees have been cleared this moss is found in abundance, and the pale-coloured, immature fruit in patches, often extensive, may be seen a long way off.

Aulacomnium palustre, Schwaeg.—Bog, Linglie Hill. A lovely moss in the field. Also found in the valley between Foulshiels Hill and Peat Law. (E.)

Bartramia pomiformis, Hedw.—Rock fissures, Corbie Linn, and on rocks nr. waterfall, Henderland Burn, etc. Fruit a beautiful delicate green when immature. (E.)

Philonotis fontana, Brid.—Bogs, marshes, and burnsides, Peat Law, Selkirk Hill, Henderland Burn, etc. Common on all heathlands, and often found in fruit.

**P. calcarea*, Schp.—Marshy ground, Selkirk Hill, and Mountbenger Law, Yarrow. A lovely moss in the field, male plants present but no fruit.

Breutelia arcuata, Schp.—On damp rocks nr. waterfall, Henderland Burn. Barren.

**Leptobryum pyriforme*, Wils.—The Haining gardens, in a flower-pot.

**Webera cruda*, Schwaeg.—Side of the Yarrow, in a wall cranny, Bowhill. Barren.

W. nutans, Hedw.—The Haining woods. (E.)

Bryum pallens, Sw.—Generally on damp clay, side of the Wark Burn, Henderland Burn, side of river Ettrick, and side of small pond in The Haining. (E.)

B. pseudo-triquetrum, Schwaeg.—Marshy places, Henderland Burn, Peat Law, etc. (E.)

B. caespiticium, L.—Dry-stone wall, roadside nr. Corbie Linn; also on wall lime in a Heatherlie garden. (E.)

B. capillare, L.—An old bridge wall nr. Hartwood Burn; wall nr. Foulshiels, and walls generally. Common.

B. argenteum, L.—On waste ground at Tweed Mill, in fruit. On cement paths at side of buildings and base of walls. On walls of stone and lime, fairly common, but not often found in open places. Generally barren. (E.)

**Mnium affine*, var. *elatum*, B. & S.—Abundant at side of Pot Loch. Barren.

**M. affine*, var. *rugicum*, B. & S.—Side of path, Bigwood, Bowhill. Barren.

M. undulatum, L.—Wall top nr. Selkirk, side of small burn nr. The Bats, in the woods of Bowhill, Philiphaugh, and The Haining. Common, and regularly barren. (E.)

M. hornum, L.—A very common moss, in woods, on river banks, at tree roots, etc., mostly barren, but often fruiting freely.

M. punctatum, L.—Wet stones, side of the Wark Burn, and common in damp places, burnsides, drains, streams, etc.

Fontinalis antipyretica, L.—Submerged in burns and running water, Henderland Burn, Whitmuir Hall Loch, Howden Glen, Bowhill, etc. Regularly barren, generally distributed. (E.)

Neckera complanata, Hübn.—The Haining, on sycamore tree trunk, often on rocks, on trees, on old walls, etc. Regularly barren. (E.)

**Antitrichia curtipendula*, Brid.—Roadside nr. Foulshiels, on damp wall face, on ash tree trunk nr. Newark Castle, and on several tree trunks on the banks of Yarrow. Regularly barren.

Porotrichum alopecurum, Mitt.—Superabundant on wet rocks in Howden Glen, and on rocks in Yarrow nr. General's Bridge. Fruit fairly common in Howden Glen, but difficult to locate. (E.)

NOTE.—12th April 1924.—Found this handsome moss fruiting abundantly in $\frac{1}{2}$ mile of Howden Glen; one stem had 11 and another 10 setae; in most cases the fruit was conspicuous.

**Anomodon viticulosus*, Hook & Tayl.—On tree trunk, side

of burn in Howden Glen, not uncommon on rocks and boulders, often fruiting freely.

Thuidium tamariscinum, B. & S.—The woods of Bowhill, Philiphaugh, and The Haining. Abundant, often found in fruit.

Climacium dendroides, Web. & Mohr.—The Pot Loch, Newark Hill, meadows in The Haining, and generally distributed in damp places, meadows, heaths, hill glens, etc. Regularly barren. (E.)

Camptothecium sericeum, Kindb.—Common on walls, rocks, tree trunks, etc.

Brachythecium rutabulum, B. & S.—Wall top nr. General's Bridge, and common on walls, stones, etc.

B. rivulare, B. & S.—Wet boulders, Henderland Burn. Barren. (E.)

B. velutinum, B. & S.—Wall nr. Philiphaugh. (E.)

B. plumosum, B. & S.—Wall top nr. General's Bridge. Common there.

B. purum, Dixon.—Big wood nr. Hartwood Burn. In fruit. Young fir wood nr. Corbie Linn, and generally fairly common, mostly barren.

Eurhynchium myosuroides, Schp.—The Haining big wood, on sycamore tree trunk, nr. base; well distributed in similar situations. (E.)

E. myurum, Dixon.—Small burn nr. Loch of the Lowes. Barren.

E. striatum, B. & S.—Wall base, moist and shady, nr. General's Bridge; also on the ground in Bowhill woods. Barren. (E.)

E. rusciforme, Milde.—On wet stones, burns in The Haining, Howden Glen, Bowhill, Henderland Burn, etc., often submerged. (E.)

**E. rusciforme*, var. *atlanticum*, Brid.—Submerged on stones, Henderland Burn. Barren.

**E. confertum*, Milde.—Red sandstone wall coping nr. Selkirk, and on wet stones, Henderland Burn.

Plagiothecium denticulatum, B. & S.—On stones, damp, shady wall nr. Whitmuir Hall; on rocks, Henderland Burn, etc.

P. undulatum, B. & S.—Fir wood, Bowhill, and common in woods, generally barren, but often in fruit.

**Amblystegium filicinum*, var. *trichodes*.—Side of spring, Foulshiels Hill. Barren. This rare moss confirmed by Messrs. W. R. Sherrin and H. N. Dixon.

**Hypnum fluitans*, var. *gracile*, Boul.—Bog, Linglie Hill. Barren.

H. commutatum, Hedw.—Very damp situations, nr. Loch of the Lowes, Selkirk Hill, valley between Foulshiels Hill and Peat Law, etc. Regularly barren. A lovely and distinctive moss, colour a rich warm brown. (E.)

H. falcatum, Brid.—Bog, Peat Law. (E.)

H. cupressiforme, L.—Red sandstone wall coping nr. Selkirk, on rotting tree stump, on the ground in The Haining woods, on banks, heaths, etc. etc. One of the commonest mosses in the district, and generally found fruiting freely.

**H. cupressiforme*, var. *filiforme*, Brid.—Oak tree trunk, The Haining woods. Barren.

H. molluscum, Hedw.—Wark Burn, also nr. Loch of the Lowes, and in Howden Glen, etc. Common, mostly barren.

**H. crista-castrensis*, L.—Bowhill woods, found in four places, well separated, generally in close association with fir trees, never common, but distinctive, and beautiful in the field. Always barren.

**H. ochraceum*, Turn.—On stones, submerged, Henderland Burn. Barren.

**H. giganteum*, Schp.—Hill drain, valley of the Catslack-burn, Yarrow; also valley between Foulshiels Hill and Peat Law. Barren.

H. cuspidatum, L.—Marshy ground, base of Howden Hill; also on stones, wall base nr. Lindean. A common district moss.

H. Schreberi, Willd.—Woods, The Haining, Bowhill, and Philiphaugh. Common, regularly barren.

Hylocomium splendens, B. & S.—Common in woods, on heaths, and hills, often found fruiting freely.

H. loreum, B. & S.—Fairly common in woods, and often in fruit.

H. squarrosum, B. & S.—In meadows, in woods, on banks, beside streams, and on heaths. A very common moss, generally barren, but several times found in fruit.

H. triquetrum, B. & S.—A striking and beautiful moss, in woods principally, all over the district; often found in fruit.

BOWHILL LOCH.

Alluvial Soil Mosses.

In connection with the introduction of electric light to Bowhill House, the Selkirkshire residence of the Duke of Buccleuch, the largest of the two lochs near the house was drained, and during the greater part of 1922 the alluvial soil forming the bed of the loch was exposed. The soil was soon carpeted with many mosses, and during the month of October, on several occasions, systematic search was made with the results noted below. It is interesting to note that out of the 20 mosses collected, 9 are new to the county list. The most prolific species of the series was *Pleuridium axillare*, Lindb. It was spread generally over the whole area, and on every occasion it was fruiting abundantly, indeed the highly coloured fruit capsules mixed with the delicate green leaves of the tiny plants formed a striking and beautiful colour feature of the loch bed, framed as they were against the dark brown soil.

Many of the mosses were in a more or less immature condition, naturally, and were difficult to identify. I take this opportunity to thank Mr. Lee for the patience and care he exercised in examining all the gatherings, several of them being in duplicate.

Catherinea undulata, Web. & Mohr.

**Pleuridium axillare*, Lindb.

**Dicranella rufescens*, Schp.

**D. Schreberi*, var. *elata*, Schp.

Pottia truncatula, Lindb.

**P. intermedia*, Fürnr.

**Trichostomum tenuirostre*, Lindb.

**Physcomitrella patens*, B. & S.

Physcomitrium pyriforme, Brid.

Funaria hygrometrica, Sibth.

Bartramia ithyphylla, Brid. (E.)

Webera nutans, Hedw.

**W. annotina*, Schwaeg.

**W. proligera*, Bryhn.

W. albicans, Schp. (E.)

Bryum pallens, Sw.

B. erythrocarpum, Web. & Mohr.

**B. atropurpureum*, var. *gracilentum*, Tayl. This moss certified by Messrs. J. R. Lee and H. N. Dixon.

B. argenteum, L.

Mnium hornum, L.

During an excursion into Moffatdale on the 17th September 1921, many mosses were collected ; the only one worthy of note, being an addition to the Dumfries list, was *Grimmia apocarpa*, var. *pumila*, Schp. It was found on boulders by the side of Loch Skene.

ADDITIONS TO THE FLORA OF ORKNEY, AS RECORDED IN
WATSON'S "TOPOGRAPHICAL BOTANY," Second Edition
(1883). By Colonel H. H. JOHNSTON, C.B., C.B.E.,
D.Sc., M.D., C.M., F.R.S.E., F.L.S.

(Read 19th June 1924.)

This paper forms a continuation of six papers on the same subject, one of which I read before the Scottish Natural History Society on 4th April 1895, and which was published in "The Annals of Scottish Natural History," No 15, pp. 173-181 (July 1895), and the other five before the Botanical Society of Edinburgh on 15th January 1914, 10th June 1920, 17th March 1921, 20th April 1922, and 19th April 1923, and which were published in the Society's "Transactions," vol. xxvi, pp. 207-217 (1914), and vol. xxviii, pp. 23-42 (1920), pp. 51-66 (1921), pp. 98-117 (1922), and pp. 174-183 (1923), respectively. Most of the plants mentioned in this paper were collected by me during the years 1922 and 1923.

Before and after the publication of the second edition of Watson's "Topographical Botany," in 1883, several of the plants mentioned in the following list have been recorded from Orkney by me and other botanists; but as the value of botanical records is greatly enhanced by the possession of authentic specimens, I have included in this list the names of all specimens in my herbarium, which are either additional to or confirm doubtful records of the plants recorded from County No. 111 Orkney in the second edition of the above-mentioned book.

In the case of those plants which have already been recorded from Orkney, references are given in the following list, under each species and variety, to the books in which the records have been published. These records are principally contained in "A Tour through some of the Islands of Orkney and Shetland," in the year 1804, by Patrick Neill (1806); "Notice of some of the rarer Plants observed in Orkney during the Summer of 1849," by John T. Syme, Esq., published in the "Transactions of the Botanical Society of Edinburgh," vol. iv, pp. 47-50 (1850); "Florula Orcadensis—A list of plants reported to occur in the Orkney Isles," by H. C. Watson,

Esq., F.L.S., published in "The Journal of Botany," No. xiii, pp. 11-20 (January 1864); Annual Reports of the Botanical Exchange Club of the British Isles; "A new List of the Flowering Plants and Ferns of Orkney," edited by W. A. Irvine Fortescue, and published in "The Scottish Naturalist" (1882-1884); "Supplement to Topographical Botany," ed. ii, by Arthur Bennett, A.L.S. (1905); and "Flora Orcadensis," by Magnus Spence, F.E.I.S. (1914).

The nomenclature followed is that of the second edition of Watson's "Topographical Botany" (1883), except in the case of species and varieties which are not recorded in that work. In the latter case the nomenclature adopted is that of "The London Catalogue of British Plants," tenth edition (1908), except where otherwise stated. Non-native plants, which have become naturalised in Orkney, are distinguished by a * prefixed to the names, and the names of casuals are printed in italics.

Of the 19 species, varieties, forms, and hybrids recorded from Orkney in the following list, 17 are native, and 2 are mere casuals introduced into Orkney through the agency of cultivation.

ABBREVIATIONS.

- "Annals Scot. Nat. Hist."=The Annals of Scottish Natural History.
 Bennett, "Suppl. Top. Bot."=Supplement to H. C. Watson's Topographical Botany, second edition. By Arthur Bennett, A.L.S. (1905).
 "Bot. Exch. Club Report" (separate Reports by the Secretary and Distributor)=Report of The Botanical Exchange Club of the British Isles, at present called The Botanical Society and Exchange Club of the British Isles.
 "Journ. Bot."=The Journal of Botany.
 "Lond. Cat."=The London Catalogue of British Plants.
 Neill, "Tour"=A Tour through some of the Islands of Orkney and Shetland, in the year 1804. By Patrick Neill, A.M., Secretary to the Natural History Society of Edinburgh (1806).
 "Scot. Nat."=The Scottish Naturalist.
 Spence, "Flora Orcadensis"=Flora Orcadensis. By Magnus Spence, F.E.I.S. (1914).
 Watson, "Top. Bot."=Topographical Botany, second edition. By H. C. Watson (1883).

CORRECTIONS.

In "Trans. Bot. Soc. Edin.," vol. xxvi, p. 222 (1914); and Spence, "Flora Orcadensis," p. 134 (1914), for "ATRIPLEX

PATULA, *Linn.*, var. ANGUSTIFOLIA (*Sm.*) (*fide* Arthur Bennett),” read ATRIPLEX HASTATA, *Linn.*, var. a. GENUINA, *Godron*, form β SALINA, *Moss et Wilmott* in “The Cambridge British Flora,” vol. ii, p. 176 (1914) (*fide* A. J. Wilmott). [=ATRIPLEX DELTOIDEA, *Bab.*, var. b. PROSTRATA of “Lond. Cat.,” ed. vii (1874); and ATRIPLEX DELTOIDEA, *Bab.*, var. b. SALINA, *Bab.* of “Lond. Cat.,” ed. x (1908).]

In “Trans. Bot. Soc. Edin.,” vol. xxviii, p. 58 (1921), in line 1, *delete* “[=M. luteus, *Linn.*].”

In “Trans. Bot. Soc. Edin.,” vol. xxviii, p. 60 (1921), in line 5 from bottom of page, *after* “p. 101” *add* (April 1899).

In “Trans. Bot. Soc. Edin.,” vol. xxviii, p. 64 (1921), for “EQUISETUM PRATENSE, *Ehrh.*,” read EQUISETUM ARVENSE, *Linn.*; and *delete* from “Confirms the record” to the end of the paragraph, “p. 97 (1914).”

In “Trans. Bot. Soc. Edin.,” vol. xxviii, p. 65 (1921), in line 21 from top of page, *after* “Scot. Nat. Hist.,” *add* No. 29, p. 58 (January 1899).

In “Trans. Bot. Soc. Edin.,” vol. xxviii, p. 115 (1922), in line 18 from bottom of page, for “*Hait*” read *Hartm.* The same correction should be made in “Scot. Nat.,” No. i—New Series, p. 24, in line 8 from bottom of page (July 1883).

In “Trans. Bot. Soc. Edin.,” vol. xxviii, p. 181 (1923), in line 10 from bottom of page, for “Dovnyby-Evie” read Dounby-Evie.

CLASS I.—DICOTYLEDONS.

Fumaria Borçei, Jordan in “Cat. Gren. (1849) et Pugillus,” p. 4 (1852) [= *Fumaria confusa*, Jordan ap. mult. auct. angl.] (*fide* H. W. Pugsley).—Turnip field, 25 feet above sea-level, Lingro, Saint Ola, Mainland, 16th September 1920, Henry Halcro Johnston. Not native. A weed of cultivation. Common. Plants in full flower and unripe fruit. Confirms the Rev. E. S. Marshall’s record of this species from Orkney (“Oatfield near Scapa Bay [Saint Ola, Mainland], plentiful,” July 1900), in “Journ. Bot.,” vol. xxxix, p. 267 (August 1901); and Alexander Somerville’s record of it from “111 Orkney,” under “*Fumaria confusa*, Jord.,” in Bennett, “Suppl. Top. Bot.,” p. 9 (1905), and in “Annals Scot. Nat. Hist.,” No. 56, p. 226 (October 1905). *Fumaria Borçei*, Jordan, is not the same

species as "*Fumaria Boræi*, Segregate," in Watson, "Top. Bot.," ed. ii, p. 25 (1883); and "Annals Scot. Nat. Hist.," No. 25, p. 44 (January 1898); nor "*Fumaria pallidiflora*, Jord., var. b. *Boræi*" of "Lond. Cat. Brit. Plants," ed. vii (1874), which is synonymous with *Fumaria purpurea*, Pugsley, in "Journ. Bot.," vol. xl, p. 135 (1902).

SAGINA MARITIMA, *Don*, var. c. DEBILIS (*Jord.*) (*fide* C. E. Salmon).—Clefts of rocks on seashore, 20 feet above sea-level, north-west end of Eynhallow, 24th August 1921, Henry Halero Johnston, native, rare, plants in unripe fruit; and rocky banks at seashore, 10 feet above sea-level, near the ruins of Saint Peter's Chapel at the east end of the Brough of Birsay, 6th August 1923, H. H. Johnston, native, rare, plants in ripe fruit, fruit-sepals 4, green, spreading—incurved at apex, capsule pale brown, dehiscing by 4 erect valves. A new record for this variety for H. C. Watson's county No. 111 Orkney. The record of this variety from Stromness Harbour, Mainland, in Magnus Spence's "Flora Orcadensis," p. 12 (1914), is an error. Dr. James Grant's specimens from this station, in Magnus Spence's herbarium, are SAGINA MARITIMA, *Don* (*fide* C. E. Salmon).

SPERGULARIA MARGINATA, *Kittel*, var. c. APTERA, *E. S. Marshall*.—Shingly seashore, 7 feet above sea-level, Little Sea, Lady, Sanday, 9th October 1921, H. H. Johnston. Native. Common. Plants in ripe fruit. Seeds not winged and without papillae. Confirms the record of this variety from Orkney ("Linksness, Hoy," July 1900), by the Rev. E. S. Marshall, in "Journ. Bot.," vol. xxxix, p. 268 (August 1901).

SPERGULARIA NEGLECTA, *Syme*, var. a. GENUINA, *Syme* [=SPERGULARIA SALINA, *Presl*, var. c. NEGLECTA (*Syme*)].—Muddy salt marsh at seashore, 10 feet above sea-level, Newbigging, Saint Andrews, Mainland, 7th September 1923, H. H. Johnston. Native. Common. Plants in ripe fruit and sparingly in flower. Flowers $\frac{1}{4}$ inch across when expanded. Petals light pinkish-purple, with a white base. Capsule slightly exceeding the persistent calyx, or, sometimes, one-third longer. Seeds brown, with prominent papillae, not winged, or, rarely, a few winged in the same capsule with wingless seeds.

SPERGULARIA NEGLECTA, *Syme*, var. b. SALINA, *Syme* [=SPERGULARIA SALINA, *Presl*].—Seashore, 7 feet above sea-

level, Oyce, Firth, Mainland, 21st August 1880, H. H. Johnston, plants in flower and fruit; sandy-muddy salt marsh at sea-shore, 7 feet above sea-level, north-west corner of Ting Park, at the Hubbin, Swanbister, Orphir, Mainland, 10th July 1914, H. H. Johnston, common, plants in flower, with 4-6 stamens; bare turfy seashore, 7 feet above sea-level, east side of Stromness Harbour, Stromness, Mainland, 13th July 1921, H. H. Johnston, very rare, plants in flower and flower-bud; and muddy marsh near the seashore, 8 feet above sea-level, between the Loch of Ayre and Bay of Ayre, Holm, Mainland, 20th August 1922, H. H. Johnston, common. Native at all these four stations in Mainland. The following notes were made by me from living plants at the Loch of Ayre, Holm, on 20th August 1922:—

Reference No. 2005.

Plants in flower and unripe fruit, and sparingly in ripe fruit. Leaves linear, subacute, with a short mucro at the apex, glabrous, green, succulent, oval in transverse section; stipules scarious, pale brown, connate round the stem, with the upper free portion triangular, acute. Bracts leaf-like, green, succulent. Flowers $\frac{1}{4}$ inch across when expanded. Petals light pinkish-purple, with a whitish base. Capsule slightly exceeding the calyx, or one-third longer. Seeds brown, without papillae, mostly without wings, but winged and wingless seeds occur in the same capsule.

See "Bot. Exch. Club Distributor's Report for 1922," vol. vi, part vi, p. 829 (May 1923).

Malva moschata, Linn., var. *a. laciniata*, Lej.—Artificial grass field laid down in permanent pasture about 1915, 60 feet above sea-level, Salis, Loch of Boardhouse, Birsay, Mainland, 27th August 1923, H. H. Johnston. Not native. A weed of cultivation. Common. Plants in full flower. Corolla and anthers pinkish-mauve. Mr. Peter Moar, residing at Stanger, Birsay, informed me, on 27th August 1923, that he first observed the Musk Mallow growing at Salis about 1920. Confirms the record of this variety, as "*Malva moschata*, Linn.," from Orkney ("Greentofts, Deerness," Mainland, August 1913), in Magnus Spence's "*Flora Orcadensis*," p. 137 (1914).

The aggregate species TARAXACUM OFFICINALE, *Wiggers*, is recorded from Orkney in Watson, "Top. Bot.," ed. ii,

p. 236 (1883), but the following two segregate species are not mentioned in that book :—

TARAXACUM LÆTIFRONS, *Dahlstedt*, n. sp.

Folia læte viridia, interdum maculis minutes passim praedita, multilobata, lobis approximatis latis brevibus \pm hamatis vel hamato-triangularibus, marginibus superioribus \pm convexis vel in lobis inferioribus \pm rectis, late dentatis, summis saepe subintegris, lobo terminali vulgo brevi sagittato-triangulari basi parce dentato-subintegrato in foliis interioribus majoribus majore et latiore, petiolis et nervo dorsali pallidis vel nervo inferne leviter colorato.

Scapi pallidi vel leviter colorati glabri vel superne areneoso-pilosi.

Involucrum olivaceo-viride subpruinatum c. 15 mm. longum, basi ovata.

Squamae exteriores late lanceolatae \pm obtuse acuminatae laxae adpressae-subpatentes, obscuriores, apice, in margine superiore et in pagina interiore \pm violascentes, interiores latiusculae e basi latiore sublineares, apice ipso \pm violascentes.

Calathium c. 35–40 mm. diametro, sat radians.

Ligulae marginales extus stria superne \pm evanescente rubro-purpurea notatae.

Antherae polliniferae.

Stylus cum stigmatibus luteus vel lutescens.

Achenium immaterum apice \pm spinulosum in pyramidem brevem conicam abiens.

TARAXACUM LÆTIFRONS, *Dahlstedt*, is closely allied to *TARAXACUM NÆVOSIFORME*, *Dahlstedt*, but it differs from this species especially through more slender growth, paler green leaves, yellow styles, and absence of pollen.

[I am indebted to Dr. Hugo Dahlstedt, Stockholm, Sweden, for the above description and remarks on this new species, and all my thirteen dried specimens of Reference No. 2265 were seen by him in March 1924.—HENRY HALCRO JOHNSTON.]

Locality.—Reference No. 2265. Grassy shell-sandy banks at seashore, 15 feet above sea-level, about 300 yards north-west of Stromness Graveyard, Innertown, Stromness, Mainland, 13th June 1923, H. H. Johnston. Native. Common. Plants in flower and sparingly in unripe fruit. Leaves dull green above,

paler green beneath, *not spotted*, with a green or purplish-green midrib. Outer phyllaries recurved both in flower-bud and in the fully expanded flower; inner phyllaries adpressed, simple at the apex (not gibbous or appendaged). Corolla yellow, striped dull crimson beneath. Style and its two recurved branches yellow.

Reference No. 2266, *TARAXACUM NÆVOSIFORME*, *Dahlstedt*, form *MEDIANS*, *Dahlstedt* (*fide* Hugo *Dahlstedt*), with leaves copiously spotted dull purple above, grew at the same station, close to *TARAXACUM LÆTIFRONS*, *Dahlstedt*, but a little nearer Stromness Graveyard than it.

TARAXACUM LÆTIFRONS, *Dahlstedt*, form or variety (*fide* Hugo *Dahlstedt*).—Reference No. 2409, of which all my six dried specimens were seen by Dr. Hugo *Dahlstedt* in March 1924. Grassy and rocky banks at seashore, 10 feet above sea-level, Furrowend, Calf Sound, Eday, 7th July 1923, H. H. Johnston. Native. Rare. Plants in fruit and sparingly in flower. Leaves dull green above, paler green beneath, *not spotted*, with a purplish-green midrib. Outer phyllaries recurved both in flower-bud and in the fully expanded flower; inner phyllaries adpressed, simple at the apex (not gibbous or appendaged). Corolla yellow, striped brownish beneath. Style and its two recurved branches yellow. Fruit-receptacle flattish-convex. Achenes pale brown.

I am indebted to Dr. Hugo *Dahlstedt* for the following remarks on my specimens of this plant:—

“*TARAXACUM LÆTIFRONS*, *Dahlstedt*, *forma vel var.* This form cannot yet be described. It seems to be allied to *TARAXACUM LÆTIFRONS*, *Dahlstedt*, perhaps only a form of it. It differs through longer lobes of the leaves, smaller more marginated a little ciliated outer phyllaries, and lighter denticulated fruits. As *TARAXACUM LÆTIFRONS*, *Dahlstedt*, it has no pollen and yellow styles.”

TARAXACUM SUBSIMILE, *Dahlstedt*, *ad interim* (*fide* Hugo *Dahlstedt*, who saw all my seven dried specimens of Reference No. 2412 in March 1924).—Reference No. 2412. Road side, 15 feet above sea-level, Carrick House, Eday, 7th July 1923, H. H. Johnston. Native. Common. Plants in fruit and sparingly in flower. Style and its two recurved branches yellow. Fruit-receptacle flattish-convex. Achenes pale brown. I am indebted to Dr. Hugo *Dahlstedt* for the following remarks

on my specimens of this plant:—"TARAXACUM SUBSIMILE, *Dahlstedt, ad interim*. Ab. T. NÆVOSO, *Dahlstedt*, cui verosimiliter est affine, foliis longius et acutius lobatis, lobis plerumque longioribus acutis interlobius angustioribus, lobo terminali acuto majore triangulari vel triangulari-hastato, colore petiolorum et nervi mediano pallidiore nec non squamis exterioribus magis angustis sat diversum videtur."

"This form seems to be related to TARAXACUM NÆVOSUM, *Dahlstedt*, but I cannot say at present whether it is to be regarded as a distinct species or but a form. It can nevertheless *ad interim* be named as above."

Reference No. 2315. Grassy and sandy banks at seashore, 15 feet above sea-level, near Stronsay Mill, south-west side of Mill Bay, Stronsay, 25th June 1923, H. H. Johnston. Native. Rare. Plants in flower and sparingly in fruit. Style and its two recurved branches yellow. Achenes brown. With reference to my eight dried specimens of Reference No. 2315, Dr. Hugo Dahlstedt, in a note, states that they "belong probably to TARAXACUM SUBSIMILE, *Dahlstedt*, but I am not fully sure of it."

CLASS II.—MONOCÔTYLEDONS.

POTAMOGETON NITENS, *Weber, form SUBINTERMEDIUS, Hagström (fide Arthur Bennett)*.—Muddy and stony bottom of a loch, under water 6 feet deep, 51 feet above sea-level, Loch of Boardhouse, near Langa Ness, Birsay, Mainland, 25th August 1923, H. H. Johnston. Native. Common. Plants in unripe fruit and sparingly in flower. Confirms Dr. G. Claridge Druce's record of this form from Orkney ("Stenness," 2nd August 1920) in "Bot. Exch. Club Secretary's Report for 1920," vol. vi, part i, p. 151 (September 1921).

POTAMOGETON PECTINATUS, *Linn., var. UNGULATUS, Hagström, form TRICHOPHYLLUS, Hagström (fide Arthur Bennett)*.—Muddy and stony bottom of a loch, under water 5 feet deep, 51 feet above sea-level, Loch of Boardhouse, near Bigbreck, Birsay, Mainland, 9th August 1923, H. H. Johnston. Native. Common. Plants in flower. A new record for this form for H. C. Watson's county No. 111 Orkney. I also collected specimens of the *var. UNGULATUS, Hagström*, in the Loch of Boardhouse, on 7th August 1923. See "Trans. Bot. Soc. Edin.," vol xxviii, part iii, p. 112 (1922).

POTAMOGETON FILIFORMIS, *Nolte, form LINIPES, Hagström* (*fide* Arthur Bennett).—Mud at bottom of water, $3\frac{1}{2}$ feet deep, in a loch, 51 feet above sea-level, north-east of the windmill pumping station (formerly a boat-house), Loch of Tankerness, Saint Andrews, Mainland, 8th September 1923, H. H. Johnston. Native. Plants in fruit. A new record for this form for H. C. Watson's county No. 111 Orkney.

ZANNICHELLIA REPENS, *Boenn.*, "Prodr. Fl. Monort.," p. 272 (1824).—Mud at bottom of water in a loch, 49 feet above sea-level, Loch of Kirbister, at the south-east side of the small island opposite Groundwater, Orphir, Mainland, 9th August 1878, and 30th August 1880, H. H. Johnston, extinct at this part of the Loch of Kirbister on 3rd August 1920; mud at bottom of water in a mill pond, 80 feet above sea-level, Gyre, Orphir, Mainland, 15th July 1886, H. H. Johnston, and 6th August 1886, William R. Linton; mud at bottom of shallow water in a mill pond, 80 feet above sea-level, Swanbister, Orphir, Mainland, 3rd August 1920, plants in flower and young unripe fruit, and 10th September 1923, plants in ripe fruit, H. H. Johnston; and mud at bottom of water, 5 feet deep, in a loch 51 feet above sea-level, Loch of Boardhouse, near Bigbreck, Birsay, Mainland, 7th August 1923, H. H. Johnston. Native and rare at all these four stations in Mainland. At the Loch of Boardhouse I raked up one stem of ZANNICHELLIA REPENS, *Boenn.*, from the bottom of the loch, but, unfortunately, I lost it, and did not find any more specimens of this species in that loch. Confirms Dr. G. Claridge Druce's record of this species (*fide* Professor C. H. Ostenfeld) for H. C. Watson's county No. 111 Orkney ("Swanbister, Orkney," 3rd August 1920), in "Bot. Exch. Club Secretary's Report for 1920," vol. vi, part i, p. 153 (September 1921). ZANNICHELLIA REPENS, *Boenn.*, in Orkney, has been recorded under the following three names:—(1) ZANNICHELLIA PALUSTRIS, *Linn.* By John T. Syme (afterwards John T. Boswell Syme, and latterly Dr. John T. I. B. Boswell) from the Loch of Kirbister, Orphir, Mainland, 25th June 1849, in "Trans. Bot. Soc. Edin.," vol. iv, part i, p. 48 (1850); and in "English Botany," ed. iii., vol. ix, p. 57 (1873), he states that "the form I found in Kirbister Loch [misprinted 'Swanbister Loch,' but corrected by him in 'Bot. Exch. Club Report for 1872-1874,' p. 41 (1875)], Orkney,

is perhaps a distinct sub-species" from *ZANNICHELLIA EUPALUSTRIS*, *Syme*, under which sub-species it is placed in that book. By H. C. Watson in his "Cybele Britannica," part iii, p. 23 (1852); "Journ. Bot.," No. xiii, p. 16 (1864), on the authority of John T. Syme; "Compendium of the Cybele Britannica," part ii, p. 346 (1869); and "Top. Bot.," ed. ii, p. 424 (1883), on the authority of John T. Syme. By Dr. A. R. Duguid in his manuscript, "Flora Orcadensis" (1858), from "Burn Bin Scart. Dr. Gillies." I have failed to find any *ZANNICHELLIA* growing in Binscarth Burn, which flows from the Loch of Wasdale to the sea at the Oyce, Firth, Mainland. By Professor J. W. H. Trail in "Annals Scot. Nat. Hist.," No. 31, p. 172 (July 1899). (2) *ZANNICHELLIA POLYCARPA*, *Nolte*. By Dr. J. T. I. B. Boswell from the Loch of Kirbister, Orphir, Mainland, August 1873, and specimens collected there in 1874 by W. A. Fortescue, in "Bot. Exch. Club Report for 1872-1874," p. 41 (1875). By Professor C. C. Babington in his "Manual of British Botany," ed. vii, p. 377 (1874), from "Kirbister [misprinted 'Swanbuster'] Loch, Orkney. Dr. Syme!"; ed. viii, p. 386 (1881), from "Orkney"; ed. ix, p. 444 (1904), from "Orkney"; and ed. x, p. 444 (1922), from "Orkney." By H. C. Watson in his "Top. Bot.," ed. ii, p. 424 (1883), on the authority of John T. Syme. By W. A. Irvine Fortescue from the Loch of Kirbister, and mill pond at Swanbister, both in Orphir, Mainland, in "Scot. Nat.," No. i—New Series, p. 25 (July 1883). By Professor J. W. H. Trail in "Annals Scot. Nat. Hist.," No. 31, p. 172 (July 1899). (3) *ZANNICHELLIA POLYCARPA*, *Nolte*, *var. b. TENUISSIMA*, *Fries*. By Dr. J. T. I. B. Boswell in "Bot. Exch. Club Report for 1875," p. 29 (1876); *ibid.* for 1876, p. 36 (1878); and *ibid.* for 1880, p. 36 (1881), from the Loch of Kirbister, Orphir, Mainland, 30th August 1880. By Professor J. W. H. Trail in "Annals Scot. Nat. Hist.," No. 31, p. 172 (July 1899). In Professor C. C. Babington's "Manual of British Botany," ed. ix, p. 444, footnote by H. and J. Groves (1904); and ed. x, p. 444, footnote by H. and J. Groves (1922). By Magnus Spence, in his "Flora Orcadensis," p. 73 (1914), from the Loch of Kirbister, and mill pond at Swanbister, both in Orphir, Mainland, and Loch of Saintear, Westray, where Magnus Spence and G. W. Scarth collected specimens on 12th September 1909. Magnus Spence's specimens from the

Loch of Saintear were seen by Dr. Hugo Dahlstedt, Stockholm, on 19th October 1923, and they were identified by him as *ZANNICHELLIA REPENS*, *Boenn.*

CAREX FLAVA, *Linn.*, *var. b.* *LEPIDOCARPA* (*Tausch.*) \times *FULVA*, *Host.* (*fide* C. E. Salmon).—Marsh, 20 feet above sea-level, Orr Shun, Sandwick, Mainland, 8th November 1922, H. H. Johnston. Native. Common. Plants in withered flower. No fruit developed. Confirms the Rev. E. S. Marshall's record of this hybrid from Orkney ("Linksness, and other places in the north part of Hoy; common;" July 1900), in "Journ. Bot.," vol. xxxix, p. 274 (August 1901). With reference to *CAREX FULVA*, *Good.*, *var. c.* *STERILIS*, *Syme* (*fide* J. T. I. B. Boswell), recorded by me (Henry Halcro Johnston) from "marsh, near South Dam, Hoy, 20th August 1885; and marsh, near North Dam, Hoy, 9th August 1886," in "Annals Scot. Nat. Hist.," No. 15, p. 181 (July 1895), Dr. G. Claridge Druce has identified my specimens from both these stations as *CAREX FLAVA*, *Linn.*, *var. b.* *LEPIDOCARPA* (*Tausch.*) \times *FULVA*, *Host.*; but Mr. C. E. Salmon has named them *CAREX FULVA*, *Host.* \times *OEDERI*, *Retz.*, *var. d.* *ÆDOCARPA*, *And.* In 1885, the late Dr. J. T. I. B. Boswell was of opinion that *CAREX FULVA*, *Good.*, *var. c.* *STERILIS*, *Syme*, "English Botany," ed. iii, p. 153 (1870), is a sterile form of *CAREX FULVA*, *Host.*, though that it is just possible that it may be a hybrid between *CAREX FLAVA*, *Linn.*, and *CAREX FULVA*, *Host.*, but it is certainly very much nearer to the *CAREX FULVA*, *Host.* See "Bot. Exch. Club Report for 1885," p. 139 (1886); "The Gardeners' Chronicle," p. 793 (18th December 1886); and "Annals Scot. Nat. Hist.," No. 15, p. 181 (July 1895). The above-mentioned three botanists agree in considering *CAREX FULVA*, *Host.*, to be one of the parents of this hybrid, but they all differ from one another as to the identity of the other parent. See "Bot. Exch. Club Secretary's Report for 1920," p. 155 (September 1921), where under "*C. FLAVA* \times *FULVA*," Dr. G. Claridge Druce records "Moss of Durkadale [Birsay, Mainland], Orkney (perhaps *lepidocarpa* \times *fulva*)."

CAREX FLAVA, *Linn.*, *var. b.* *LEPIDOCARPA* (*Tausch.*) \times *OEDERI*, *Retz.*, *var. d.* *ÆDOCARPA* *And.* (*fide* C. E. Salmon).—Marsh, 20 feet above sea-level, Orr Shun, Sandwick, Mainland, 4th September 1922, H. H. Johnston. Native. Common. Plants in withered flower. No fruit developed. A new

record for this hybrid for H. C. Watson's county No. 111 Orkney.

CAREX FULVA, *Host.* \times *OEDERI*, *Retz.*, *var. d.* *ÆDOCARPA*, *And.* (*fide* C. E. Salmon).—Marsh, 30 feet above sea-level, Work, Saint Ola, Mainland, 28th August 1922, H. H. Johnston. Native. Rare. Plants of this hybrid grew close to both parents, and they had withered flowers, and no fruit developed, except in one plant which had unripe fruits in the upper two spikes and no fruit developed in the lowest spike. Confirms the Rev. E. S. Marshall's record of this hybrid from H. C. Watson's county No. 111 Orkney ("Stenness, Mainland," July 1900), in "Journ. Bot.," vol. xxxix, p. 274 (August 1901). With reference to *CAREX FULVA*, *Good.*, *var. c.* *STERILIS*, *Syme* (*fide* J. T. I. B. Boswell), recorded by me (Henry Halcro Johnston) from "marsh, Piggar, Swanbister, Orphir, Mainland, 5th August 1885; marsh, near South Dam, Hoy, 20th August 1885; and marsh, near North Dam, Hoy, 9th August 1886," in "Annals Scot. Nat. Hist.," No. 15, p. 181 (July 1895), Mr. C. E. Salmon has identified all my specimens from these three stations as *CAREX FULVA*, *Host.* \times *OEDERI*, *Retz.*, *var. d.* *ÆDOCARPA*, *And.*; but Dr. G. Claridge Druce has named the same specimens from the two stations in Hoy as *CAREX FLAVA*, *Linn.*, *var. b.* *LEPIDOCARPA* (*Tausch.*) \times *FULVA*, *Host.* See my remarks under the last-named hybrid at p. 93 of this paper; "Bot. Exch. Club Report for 1885," p. 139 (1886); "The Gardeners' Chronicle," p. 793 (18th December 1886); and "Annals Scot. Nat. Hist.," No. 15, p. 181 (July 1895).

TRITICUM JUNCUM, *Linn.* \times *REPENS*, *Linn.* (*fide* G. C. Druce).—The same specimen was identified as *TRITICUM ACUTUM*, *DC.*, by the late Dr. J. T. I. B. Boswell, but De Candolle's species of this name has not been found in Great Britain. Scapa, Saint Ola, Mainland, 25th July 1876, H. H. Johnston. Native. This hybrid has been recorded from Orkney under the erroneous name of *TRITICUM ACUTUM*, *DC.*, by Dr. J. T. I. B. Boswell from Scapa in Saint Ola, and Hubbin in Orphir, both in Mainland, and Hoxa in South Ronaldsay, in his manuscript "Florula Orcadensis" (of which I have a copy in my possession, dated 11th January 1881); by H. C. Watson in his "Top. Bot.," ed. ii, p. 503 (1883), on the authority of John T. Syme; by W. A. Irvine Fortescue in "Scot. Nat.," No. iii—New Series, p. 111 (January

1884); by Professor J. W. H. Trail in "Annals Scot. Nat. Hist.," No. 33, p. 42 (January 1900); and by Magnus Spence, in his "Flora Orcadensis," p. 91 (1914), from Scapa, Saint Ola, in Mainland, and Hoxa Links in South Ronaldsay.

CLASS III.—CRYPTOGAMS.

OPHIOGLOSSUM VULGATUM, *Linn.* (name confirmed by Arthur Bennett).—Moist natural pasture, 60 feet above sea-level, two miles inland from the sea, Bigbreck, Birsay, Mainland, 9th August 1923, and 25th August 1923, H. H. Johnston. Native. Common. Plants in fructification. Fronds 3–10 inches high. Mr. George William Scarth, in a letter dated 17th September 1919, informed me of this station, and he personally pointed it out to me on 9th August 1923. Confirms the record of this species from H. C. Watson's county No. 111 Orkney in the Rev. Dr. George Barry's "The History of the Orkney Islands," ed. i, p. 280 (1805), in "Wet meadows"; and ed. ii, p. 288 (1808). In H. C. Watson's "Top. Bot.," ed. ii, p. 525 (1883), the type of this species is not recorded from Orkney; and the words "Syme sp. a var." should be deleted, because the variety referred to is the *var. b. AMBIGUUM*, *Coss. et Germ.*, which is recorded from Orkney in that book, on the authority of John T. Syme. See "Journ. Bot.," No. xiii, p. 17 (January 1864); and "Annals Scot. Nat. Hist.," No. 34, p. 106 (April 1900). OPHIOGLOSSUM VULGATUM, *Linn.*, *var. b. AMBIGUUM*, *Coss. et Germ.* [= *var. b. POLYPHYLLUM*, *Braun.*], has only been found at the sea-coast in Orkney, in eight different islands, and in drier natural pasture than that in which the type of the species grows at Bigbreck in Birsay, Mainland.

THE MORPHOLOGY AND PHYSIOLOGY OF THE LEAVES OF
SOME CRASSULACEAE. By CHRISTINA J. KEAN, B.Sc.

(Read 19th June 1924.)

According to De Bary (1), the Crassulaceae have a modification of the ordinary reticulate venation of Dicotyledonous leaves. In the thick leaves there is a divergence of bundle branches and meshes towards the surfaces. Peripheral endings, as found in the shrubby species of *Crassula*, have not been observed in *Sempervivum*. In *Crassula arborescens* the vascular bundle terminates in two branches ending at hydathodes.

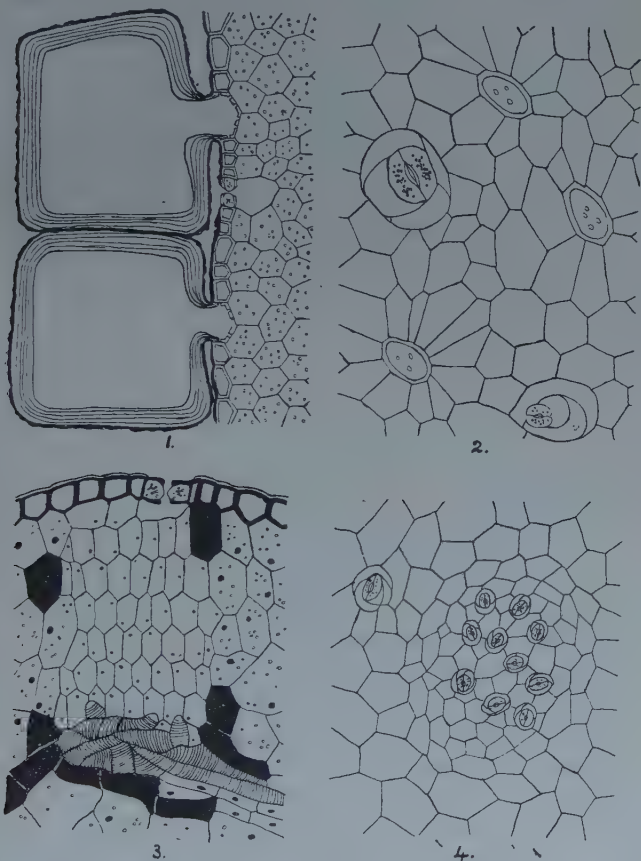
Hydathodes occur on both surfaces in *Crassula arborescens*, and as a single row within the margins only, on both surfaces, in *Rochea coccinea*, according to De Bary, and in *Bryophyllum*. Solereder (2) and De Bary state that the hydathodes have usually several pores smaller than the air-pores but only one in *Rochea coccinea* exceeding the air-pore in size.

The hydathodes are of the epithem type. The epithem consists of elongated cells of closely packed parenchyma, according to De Bary, but Haberlandt (4) has observed isodiametric cells with intercellular spaces in certain forms.

The species here dealt with are:—*Rochea falcata*, DC.; *R. coccinea*, DC.; *Crassula arborescens*, Willd.; *Bryophyllum crenatum*, Baker; *Sempervivum triste*, Baker.

Rochea falcata.—The adult leaves are about 110 mm. long and 50 mm. wide with a thickness of 10 mm. towards the base, thus showing marked succulence. In shape the leaf is falcate, apetiolate, with a slightly decurrent base. The whole surface is covered with transparent, colourless, bladder hairs fitting together to form a complete covering for the leaf. The peculiar grey-green colour is due to this covering. In a transverse section of the leaf (fig. 1) each hair appears T-shaped with a convex outer wall. Its basal wall bears simple pits. The close packing gives the head a polygonal appearance in surface view. The wall has an inner, stratified, cellulosic layer, 15 μ in thickness, and a thin outer cutinised layer bearing cuticular protuberances. The shape of the hairs is well suited to give an extra covering for the leaf. An enclosed

space is thus left between the epidermis and the expanded part of the hairs, probably to ensure a saturated atmosphere in the region of the hydathodes. The protoplast consists of a thin peripheral cytoplasmic layer with a large nucleus usually occupying the upper part of the hair. Calcium oxalate is present in solution in the large vacuole.



The leaves are opposite and in pairs, each pair being set at an oblique angle to the preceding and succeeding pairs. They are "klinotropic" (3); that is, the young leaves grow vertically with their inner surfaces and apposed margins overlapping, but with age they bend sideways and outwards till their median planes are oblique. They are also "antitropic," the leaves of each pair falling on opposite sides of the plane

passing through both bases. This is brought about by growth in length and basal thickening of the adaxial margins giving an asymmetric part to the leaf.

The leaf structure is almost centric. The epidermis consists of a single layer of cells, one-tenth of which form hairs. Stomata and hydathodes occur on both surfaces. The mesophyll consists of isodiametric cells forming succulent parenchyma. Towards the leaf surfaces the cells are slightly elongated and more closely packed. Numerous normal, collateral bundles occur throughout the mesophyll. Some are connected with epithem hydathodes.

The leaf trace consists of three vascular bundles coming off independently from the stem stele. By division in a vertical plane each gives three meristeles in the cortex. There are thus nine primary meristeles. Each of these divides in a horizontal plane to give an upper, a central, and a lower system of meristeles which pass into the leaf. A few branches come off from the central meristeles above and below but all end blindly. The three systems are thus quite independent of each other after entering the leaf. Some of the meristeles of the accessory systems fade out as they course up the leaf but others terminate at the hydathodes. The three meristeles giving the central system divide in the cortex in the horizontal plane to give about twelve. The bundle giving the meristele corresponding to the midrib of normal dicotyledonous leaves comes off first and is laterally situated. The other lateral meristele feeds the asymmetric part.

Hydathodes may be seen on an average of three to seven in the area of the field of the microscope (2.27 sq. mm.). Two hydathodes frequently occur together, separated only by the stomatal girdle cells and two long, narrow epidermal cells. There may be one or two hydathodes or only one or two stomata on the floor of the cavity between a group of hairs. Hydathodes and ordinary stomata may occur in the same area; for example, two hydathodes and one stoma. Hydathodes and ordinary stomata occur in the proportion of about one hydathode to thirty stomata, but this does not hold where two hydathodes occur together. There are none actually marginal.

Each hydathode has one large stoma (fig. 2), the guard cells of which measure $55 \times 10 \mu$. The width of the slit is 5μ .

The stomata vary from 50 to 80 per sq. mm. The guard cell is $30 \times 5 \mu$ and the pore is 2.5μ in width. Each stoma is surrounded by an auxiliary system of three or more crescent-shaped cells.

In *Rochea coccinea* hydathodes are found as a single sub-marginal row on the upper surface and uniformly distributed over the under surface, contrary to De Bary's observation that they occur submarginally only on both surfaces. On the under surface two or three occur in an area of 2.27 sq. mm. Associated with each is one large pore, the guard cell of which measures $55 \times 20 \mu$ and the slit 5μ . Ordinary stomata occur in the proportion of 16 per sq. mm. on the upper and 22 per sq. mm. on the under surface. The guard cells measure $45 \times 10 \mu$ and the width of the pore 2.5μ .

The hydathodes are most numerous in the former of these species, but they are also better protected in that they have the covering of hairs. The ordinary stomata are also very numerous in the former. The stomatal slits are half as wide, in both species, as the pore slits.

The whole hydathode is oblong in longitudinal section and circular in transverse section, measuring 275μ in length and 150μ in width. The long axis is at right angles to the epidermis. The structure consists of a mass of parenchyma, the epithem tissue, with a vascular base and a stomatal apex (fig. 3). The epithem is composed of hexagonal, prismatic, parenchymatous cells of small size with pyramidal ends. There are no intercellular spaces, and the epithem units are about one-fifth of the size of the mesophyll cells. The xylem, in the form of spiral tracheids, passes from the bundles of the accessory systems to the base of the epithem, where it broadens out to form a solid hemisphere. The ends of the tracheids interpectinate between the epithem units. Each hydathode has one large pore, beneath which is a very small chamber. Surrounding the epithem tissue is a sheath one cell deep, the units of which are smaller than the mesophyll cells. They are mainly tannin cells, but a few do not give any tannin reaction.

Haberlandt (4) states (i) that certain epithem hydathodes may absorb fluid from the exterior as well as pass it out; (ii) that the outward passage of water is a process sometimes of filtration, sometimes of secretion; (iii) that the hydathode

action may ensure a secretion current to supplement a weak transpiratory current. The process here would apparently be one of secretion. As bearing on these points, the following experiments were performed. Leaves with the cut basal end dipping in eosin solution were found, after two days, to have the meristemes and epithem tissue injected, showing that a secretion current is present in this case. Then a whole plant was left, unwatered, in the dry air of the laboratory, one leaf dipping in eosin solution, for four weeks. The solution showed marked decrease in volume but no absorption by the hydathodes took place. The other leaves lost their plumpness but new leaves continued to form, indicating that the plant was using up its water store to allow growth to proceed. It was further noticed that the solution was sucked up for a considerable distance between the hairs, the cavities thus acting as a capillary system. Much of the solution was absorbed in the thick, stratified walls of the hairs, and even after soaking for about two days in water the walls still retained their pink coloration. This seems to indicate that the hairs but not the hydathodes act as an absorbent system. The water given off by the hydathodes is probably not evaporated but reabsorbed by the hairs. This would explain the presence of the pitted basal wall through which the liquid might pass more readily to the mesophyll.

Crassula arborescens.—The leaves are flattened pyriform in shape, and measure 55 mm. in length and 40 mm. at the widest part. They are less succulent than those of *Rochea falcata*, being only 5 mm. thick. They are opposite and decussate, with oblique orientation, and are separated by internodes about an inch in length. The petiole is very short and massive. The distribution of tissues is similar to that of *Rochea falcata*, but there are no hairs. The cell sap of a few marginal, sub-epidermal cells contains a red anthocyanin pigment, and the whole leaf has a covering of wax.

The vascular system arises as a single leaf trace. It branches in the cortex in the horizontal plane to give a stout central and two small lateral meristemes which pass into the leaf. The small ones end about one-fourth up the leaf. The central meristeme forms the midrib. All three branch profusely. The branches pass forward and outwards in all directions, some fading out and others passing to hydathodes. To supply the

submarginal series, the branches, including the end of the midrib, bifurcate in a vertical plane and each branch passes to a hydathode on the upper or under surfaces respectively. The surface hydathodes are supplied in a similar manner by a bundle which has just bifurcated. Two hydathodes in close proximity are thus supplied.

The hydathodes can be seen as translucent spots all over the upper surface of the leaf, but they are more numerous towards the margins. On the under surface are two alternating sub-marginal rows and a few scattered irregularly a little further in. Taking the area of the field of the microscope, different parts of a section showed from one to four hydathodes. The average number is thus less than in *Rochea falcata*. Each hydathode communicates with the exterior by from ten to twenty small pores occupying an area of from 0.05 sq. mm. to 0.16 sq. mm. and embedded amongst small, thin-walled epidermal cells (fig. 4). The guard cells vary from $35 \times 5 \mu$ to $40 \times 7 \mu$ in the respective pores of one hydathode, but the average size of the pores for all the hydathodes is constant. They do not vary in size in relation to the area they occupy. The width of the pore is 2.5μ . The hydathodes with the smaller areas have fewer pores than those with the larger areas, but in the smaller areas the number of pores is proportionately larger, as is seen in the following table :—

Area of hydathode.	No. of pores.	No. per unit area (1 sq. mm.).
0.05	10	200
0.13	15	115
0.16	20	125

In size and structure the whole hydathode is similar to that of *Rochea falcata*.

The ordinary stomata are equally distributed over both surfaces, the average numbers being 21 to 32 per sq. mm. The guard cells measure $50 \times 15 \mu$ and the width of the pore 5μ .

Bryophyllum crenatum.—The adult leaves of this plant are ovoid, with a petiole about 20 mm. long. The lamina measures 40 mm. in length and 25 mm. in width. The margins are crenate. The orientation is dorsiventral and the leaf arrange-

ment opposite and decussate. In the adult plant the internodes are several inches long. There are no hairs and only a slight covering of wax. The mesophyll consists of smaller cells than those of *Rochea*. The pink colour of the leaf is due to a sap pigment in the cells surrounding the vascular bundles.

In this case three bundles come off the stem stele and pass directly into the petiole, the two lateral bundles giving off short branches in their course and ending in the region of the first tooth after branching and anastomosing. Three of the branches end at the hydathode in that area. The central meristele becomes the midrib and gives off pinnate branches which further branch reticulately and anastomose. Each hydathode has three systems of tracheids passing to its base. One enters basally and two laterally, the latter forming a system passing submarginally right round the leaf. There is thus a very plentiful water supply in the region of the marginal teeth. Besides the anastomosis at the hydathodes, the sub-marginal system is joined at the angles by a branch from one of the pinnate branches of the midrib. This rich vascular supply may have some connection with the prolific development of propagative buds so characteristic of the species. The angles nearest the apex are supplied by branches directly off the midrib along with others which have ramified further through the leaf, and in this region the best developed buds are usually found.

Hydathode distribution is much more restricted in this species. They were observed near the apex of each tooth, opening on the under surface. They average about fourteen per leaf according to the number of teeth. In the lower epidermis each hydathode area is occupied by three to six small pores, the guard cells of which measure $25 \times 5 \mu$, the width of the pore being 1.25μ . The hydathode has an average surface area of 0.013 sq. mm. The number of pores is not in any way proportional to the area in this case.

Area of hydathode.	No. of pores.	No. per unit area (1 sq. mm.).
0.013	3	230
0.013	6	460

The ordinary stomata have an average distribution of 50 to 53 per sq. mm. over both surfaces. The guard cells are $30 \times 5 \mu$ in surface and the pore 2.5μ in width.

In the last two species dealt with the stomatal slits are twice as wide as the pore slits. The small pore slits are compensated for by increase in the number of pores. In *Rochea* water will pass out at a certain rate. It is possible that the rate will be the same from the sum of the pores in *Crassula* and *Bryophyllum* in proportion to the rate of transpiration in the different forms. In terms of unit area *Bryophyllum* has more numerous pores and stomata than *Crassula*, and the pores and stomata of the former are smaller both in the size of their guard cells and the width of the slits. Increase in number in the former will compensate for decrease in size.

In size and structure the whole organ is similar to that of *Rochea falcata*. The tannin sheath is not nearly so well marked in this case, only a few cells showing the reactions. In all these cases the hydathodes, since they have no intercellular spaces, are secretory. This agrees with the fact that the plants show such xerophilous features as succulence, wax or hairs. The process therefore causes an extra suction to absorb all the moisture possible from the soil.

Sempervivum triste.—The leaves are oblong-ovate with an acuminate tip. There is a single marginal row of unicellular capitate hairs. The cell sap of the epidermal cells contains an anthocyanin pigment giving the leaves a dark reddish-brown colour. The leaf arrangement is spiral with the leaf bases slightly oblique to the horizontal, the whole collection forming a close rosette.

The vascular system arises as a single leaf trace. In the cortex it branches in a vertical plane to give a large central meristeles and one or two small branches above and below. The small ones anastomose with similar branches from the traces above and below. The central meristeles then branches in the cortex parallel to the leaf base to give three meristeles which pass almost to the tip of the leaf.

There are no hydathodes and the stomata are equally distributed over both surfaces. They occur on an average of 65 per sq. mm. They are most numerous in this species which has no hydathodes, excepting *Rochea falcata* where they are afforded the extra protection already referred to. This

indicates a stronger transpiratory current. The guard cells measure $30 \times 5 \mu$, which is the same measurement as that observed for *Rochea falcata*. The pores are 5μ in width.

SUMMARY.

1. Hydathodes were observed in *Rochea*, *Bryophyllum*, and *Crassula*. In *R. coccinea* they were observed over the whole of the under surface of the leaf and not submarginally only.

2. Solitary pores were found in both species of *Rochea*.

3. The hydathodes secrete but do not absorb water. They act as an extra suction force in the leaf. In *Rochea falcata* the hairs are probably absorptive.

4. The vascular system may arise as three bundles or as a single leaf trace.

5. In *Rochea falcata* a large number of meristeles enter the leaf. In the other forms examined there were only three.

6. Free endings were observed in *Rochea falcata* and *Crassula arborescens* and anastomosis in all but the former.

7. In *Bryophyllum* there is a rich marginal vascular system which may account for the free production of propagative buds in this species.

The writer has to express her indebtedness for facilities and assistance afforded her in the Botanical Department, St. Andrews University, where this investigation was carried on.

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- (2) SOLEREDER: Systematic Anatomy of the Dicotyledons, Eng. trans., 1908.
- (3) GOEBEL: Organography of Plants, Eng. trans., 1900.
- (4) HABERLANDT: Physiological Plant Anatomy, Eng. trans., 1914.

EXPLANATION OF DIAGRAMS.

- Fig. 1. Transverse section of a leaf of *Rochea falcata* showing hairs with a pitted basal wall, an inner, thick, stratified, cellulosic layer, and a thin external cuticle.
- Fig. 2. Epidermis of *Rochea falcata* showing a large hydathode pore, an ordinary stoma, and three hair bases.
- Fig. 3. Longitudinal section of a hydathode of *Rochea* with its tannin sheath. It shows the epithem tissue with its vascular base and stomatal apex.
- Fig. 4. Epidermis of *Crassula arborescens* showing a collection of small hydathode pores among small, thin-walled, epidermal cells, and one ordinary stoma.

NOTE ON THE LATERAL LINES OF THE PETIOLES OF
FERNS. By MARGARET R. MITCHELL, B.Sc.

(Read 19th June 1924.)

Flanking the petioles of some Ferns are two narrow longitudinal lines, one on either side, differing in colour from the general surface of the petiole, and visible to the naked eye. The lines in most cases mark the position of strips of epidermis containing stomata, which are not found in the epidermis of any other part of the petiole. These "stomatal strips" usually cover areas of parenchymatous tissue with intercellular spaces, which interrupt the sclerosed hypoderma and communicate with the general petiolar parenchyma. The stomatal strips and parenchyma vary in extent in different ferns, and in those with creeping rhizomes the parenchyma may be continued in two lateral lines throughout the rhizome, uncovered by epidermis.

Reference to the above is made by De Bary in Comparative Anatomy of the Phanerogams and Ferns (English edition, p. 405), and by Bower in his monograph on Comparative Morphology of the Leaf in the Vascular Cryptogams and Gymnosperms, 1884 (Trans. Roy. Soc., vol. clxxv). He describes the occurrence in *Aspidium Filix-Mas* of a "longitudinal weal on each side of the base of the phyllopodium and pinnae," easily recognised in the mature leaf. He regards this as the representative of, or a suppressed form of, the wing-like development, which in other cases is continuous to the base. He considers the leaf as a whole as an axis, the "phyllopodium," which, in simple forms like that of *Pilularia*, is unbranched and uniform in structure, but in higher forms such as *Osmunda* is a structure winged to its extreme base. Further differentiation is seen in *Angiopteris*, in which the phyllopodium is only slightly winged, and the winged developments are chiefly relegated to branchings of a higher order. The phyllopodium above the stipules is almost cylindrical, with traces of longitudinal markings.

This investigation deals particularly with the lateral lines of (1) *Pteris aquilina*, Linn.; (2) *Pt. tremula*, R. Br.; (3) *Pt.*

cristata, Moore; (4) *Pt. macilentata*, A. Rich.; and generally with those of (5) *Aspidium aculeatum*, Sw.; (6) *Dictymia attenuata*, Sm.; (7) *Polypodium vulgare*, Linn.; (8) *Scolopendrium vulgare*, Sm.; (9) *Polypodium serpens*, Sw.; (10) *Lomaria Spicant*, Desv.; (11) *Todea hymenophylloides*, A. Rich.; (12) *Hymenophyllum*, sp.

1. *Pteris aquilina*.—In the petiole two longitudinal stomatal strips of epidermis are found flanking the epigeal part of the petiole, one on either side. Underlying all other parts of the epidermis is a hypoderma of four or five layers of sclerenchyma fibres, the walls of which are thick, stratified and lignified, and contain numerous simple pits. Subjacent to the stomatal strip, however, a complete break in the hypoderma occurs, and parenchymatous tissue, of rounded, loosely packed cells, with very large intercellular spaces, is found (fig. 3). This tissue is continuous with the general petiolar parenchyma.

The stomatal strips can be distinguished with the naked eye by their colour, which is brighter green than that of the surrounding surface. Below ground level the petiole is dark brown in colour, but lateral lines which are lighter brown can still be seen. The tissue of these lines is a continuation of the parenchyma underlying the stomatal strips. The epidermis covering this tissue is broken and severed from it at ground level (fig. 4), so that the tissue of the hypogeal parts of the lines is exposed cortical tissue, lying between sclerotic masses covered by epidermis. As seen in tangential section, the tissue is composed of irregularly shaped cells of very sinuous outline, with large intercellular spaces (fig. 2). The cell walls are thick and pitted. The tissue is four or five cells in width, and several cells in depth.

The branches and leaves of the rhizome arise alternately in two lateral rows (fig. 1). Two lines, which are continuations of the stomatal strips of the petioles, flank the rhizome throughout. They are continued up the sides of the lateral branches and leaves, with the bases of which they are in line. Thus of the two lines of a petiole, the one from the "upper" side is continued backwards along the rhizome, the base of the petiole being twisted so that the leaf grows upwards. The other line, from the "lower" side, is continued forward along the rhizome to the next leaf but one, to the "upper"

side of which it passes. The lines are distinguishable on the apices and leaf primordia. The tissue of the lines on the rhizome is similar to that of the lines on the hypogeal part of

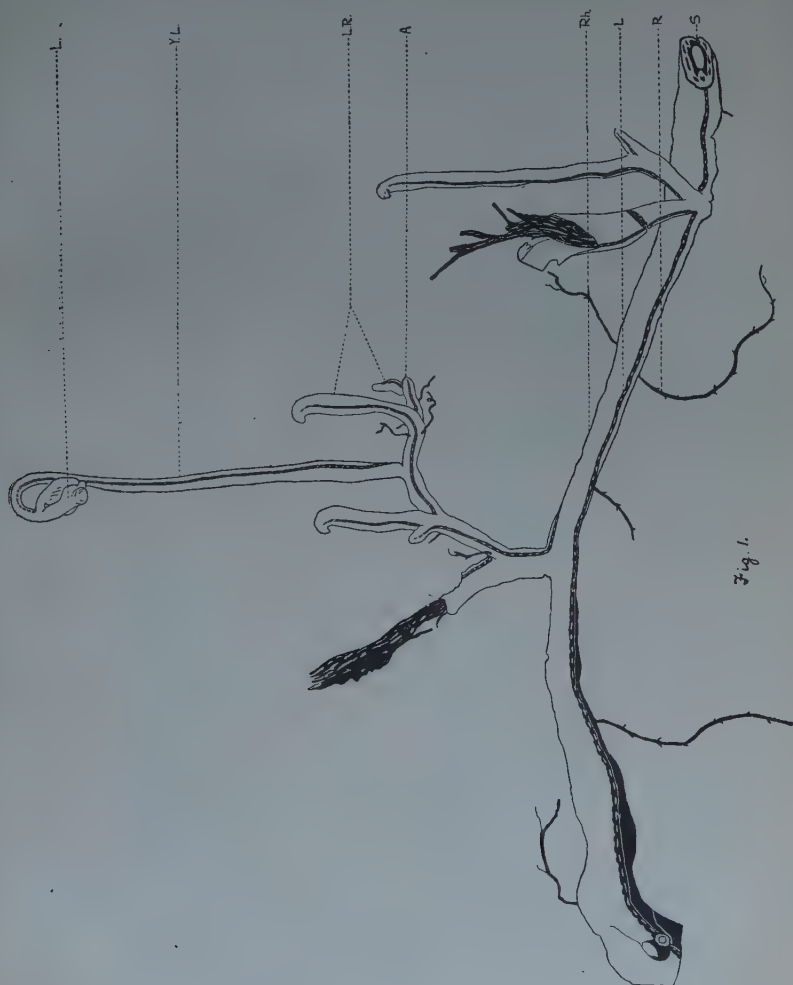


Fig. 1.

the petiole. It is seen about 0.2 inch from the apex, although there the cells are small and the walls thin. The lines on the leaf primordia have epidermis which contains stomata within 0.15 inch of the tip.

The number of stomata in a strip on a petiole is not uniform.

Passing down from the base of the lamina, the number first increases, then decreases, and subsequently increases rapidly

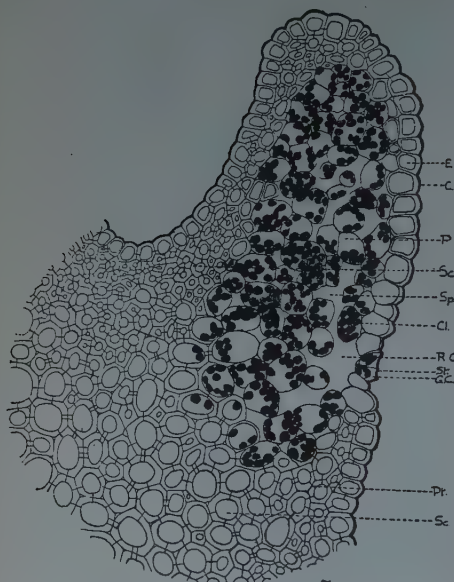


Fig. 5.

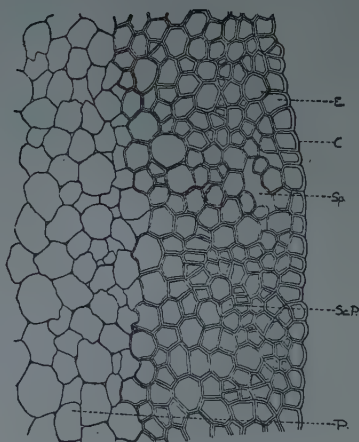


Fig. 3.

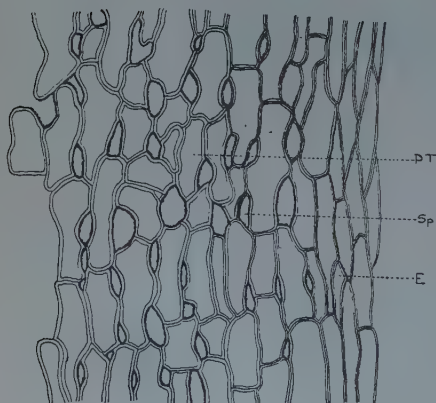


Fig. 2.

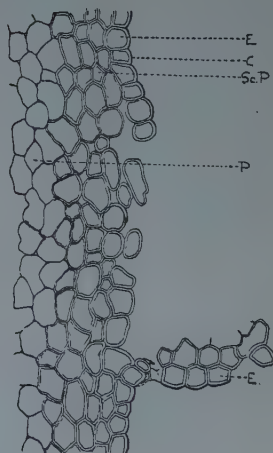


Fig. 4.

in the inch immediately above ground level. The change in the nature of the tissues of the line follows closely on this increase in number of stomata. The numbers in a young petiole were found to be as follows :—

Number of stomata in upmost half inch	=107	} increase.
" " next "	=150	
" " next "	=154	
" " next inch	=206	} decrease.
" " " "	=157	
" " " "	=133	
" " " "	=131	
" " " "	=113	
" " " "	=180	rapid increase.
Total length of petiole=11 inches.		

2. *Pteris tremula*.—A similar condition is found in the petiole of this species as in the epigeal parts of the petiole of *Pteris aquilina*, but in this case it extends throughout the whole length of the petiole, and the greatest number of stomata is found in the lowest inch. The rhizome is vertical with very short internodes, so that the leaves form a crown near the apex, and adventitious roots arise from the rhizome near their bases. The stomatal lines disappear at the position of the insertion of the leaves into the rhizome.

3. *Pteris cristata*.—The petiole of this species also has two lateral longitudinal strips of epidermis containing stomata, but these are few in number. The number decreases basipetally until in the lowest eighth no stomata are present. There is an almost complete hypoderma of five or six layers of sclerenchyma, but a break in it occurs internal to each stoma, so that there is an islet of parenchyma, with large intercellular spaces, communicating with the general petiolar parenchyma. The hypoderma of sclerenchyma is complete above and below each stoma.

4. *Pteris macilenta*.—On the petiole, in this case, two lateral longitudinal lines can be distinguished by their colour, which is darker than that of the surrounding surface. The epidermis, however, contains no stomata. There is a continuous hypoderma of five or six layers of sclerenchyma, except in the position of the two lateral lines, where there are only two or three layers of it. Tannin in the parenchyma is most abundant internal to this, accounting for the dark colour of the lines. Stomata are found in lateral strips of the epidermis of the primary and secondary branches of the leaf. These facts

suggest the idea that lateral stomatal strips were once present on this petiole.

5. *Aspidium aculeatum*.—The same condition is found in the petiole as in that of *Pteris tremula*.

6. *Dictymia attenuata*.—In this case, the petiole throughout its whole length has lateral wings, which diminish gradually, passing down the petiole until they disappear at its base. Stomata are found on the under surface of the wings. No trace of them is found on the rhizome, which is horizontal.

7. *Polypodium vulgare*.—Lateral wings are represented in the petiole only by two flanges which extend from the base of the lamina down about seven-eighths of the petiole, one on either side. They gradually diminish in their downward passage to the point of their disappearance. Stomatal strips are found on the abaxial sides of the flanges and disappear simultaneously with them. A hypoderma of six or eight layers of sclerenchyma fibres is found under the epidermis of the whole of the petiole except the flanges. At the upper end of the petiole the bulk of the tissue of each flange is parenchyma, with intercellular spaces, composed of loosely packed, thin-walled cells, richer in chloroplasts than those of any other part of the petiolar parenchyma (fig. 5). This tissue is found underlying the stomatal strip throughout its whole length, but decreases in amount along with the decrease in size of the flange, and disappears with it. It is thus a prolongation of the mesophyll of the lamina down seven-eighths of the petiole, ending blindly in the hypoderma.

8. *Scolopendrium vulgare*.—In this case lateral wings are represented only by two very small flanges, extending down a sixth of the petiole, and by stomatal strips on their abaxial surfaces which are continued down half to two-thirds of the petiole. The stomata are reduced, with small respiratory chambers, and are probably not functional. There is a complete hypoderma of six to eight layers of cells of stereom tissue, in this case collenchyma, which is unbroken internal to the stomatal strips.

9. *Polypodium serpens*.—The leaf is small and ovoid, and the lamina becomes narrower towards its base, merging gradually into the petiole, which is about half an inch long and cylindrical. Stomata are found sunk in crypts, on the under

surface of the lamina throughout its entire length. No wings nor stomata are present on the petiole.

In *Lomaria Spicant*, *Todea hymenophylloides*, and the species of *Hymenophyllum* examined, no traces of side wings are found on the petioles. The epidermis in each case contains no stomata, and there is a complete hypoderma of sclerenchyma.

These stomatal strips on the petioles of ferns, as well as the flanges found in some species, and the subjacent tissues, appear to be vestigial remains of side wings such as Bower describes. Perhaps the strongest indication of this is in the flanges of *Polypodium vulgare*. The existence of stomatal strips on the branches only of the leaf of *Pteris macilenta* is in accordance with his statement regarding the relegation of winged developments to branchings of a higher order in *Angiopteris*.

Taken in the above order, the ferns examined, with the exception of *Aspidium aculeatum*, which is similar in this respect to *Pteris tremula*, show two progressive series. In the one, from *Dictymia attenuata* to *Scolopendrium vulgare* flanges are present from a greater to a less extent. In the other series, from *Pteris aquilina* to *Pteris macilenta*, only stomatal strips are present, varying considerably in extent.

The occurrence, throughout the rhizome of *Pteris aquilina*, of prolongations of the parenchymatous tissue underlying the stomatal strips of the epidermis of the petioles, suggests that the rhizome was at one time epigeal, and is a sympodium originally formed of a succession of fused persistent leaf bases. Another view, which lends support to Bower's phyllopodium theory, is that the rhizome represents the main axis of a phyllopodium with unlimited apical growth, of which branches form what we consider as leaves.

The writer desires to express her indebtedness for facilities and assistance afforded her in the Botanical Department, University of St. Andrews, where this work was carried on.

DESCRIPTION OF FIGURES.

1-4. *Pteris aquilina*.

1. Rhizome, young leaf and leaf rudiments, arrangement of lateral lines, $\times \frac{1}{2}$.
2. Tang. S. of hypogaeal portion of petiole, showing nature of line tissue, $\times 180$.

3. Trans. S. near ground level of same, stomatal band and subjacent petiolar tissue, $\times 180$.
4. Trans. S. at ground level of same; epidermis breaking up, $\times 180$.
5. *Polypodium vulgare*. Trans. S. of petiole, upper part, showing lateral flange and stomatal line, $\times 180$.

KEY TO LETTERING OF FIGURES.

A.=Apex.	P.=Parenchyma.	S.=Stereom ring in
C.=Cuticle.	Pt.=Pit.	rhizome.
Cl.=Chloroplast.	P.T.=Parenchymatous	Sc.=Sclerenchyma.
E.=Epidermis.	tissue of line.	Sc.P.=Sclerotic paren-
G.C.=Guard cell.	R.=Root.	chyma.
L.=Line.	R.C.=Respiratory	Sp.=Intercellular space.
La.=Lamina.	chamber.	St.=Stoma.
L.R.=Leaf rudiment.	Rh.=Rhizome.	Y.L.=Young leaf.

OBITUARY NOTICES.

EUGENE WARMING.

The death of Professor Eugene Warming of Copenhagen means the loss to the Botanical Society of Edinburgh of one of its older Honorary Fellows, for he was elected in 1886. Dr. Warming was born 3rd November 1841 at Mano in Jutland and passed his boyhood near the Schleswig-Holstein frontier, an influence that developed a strong patriotism. The plants of Jutland were familiar to him from his childhood. Warming's great work was the revival of the study of plant morphology, particularly with reference to environment, or what is now called Plant Ecology. Remembering this, it is of interest to trace the influences which seem to have moulded Eugene Warming. He graduated in 1868 and received his Doctorate in 1871. During his undergraduate years he spent fully three years at Lagoa Santa in Brazil, and studied at the universities of Munich and Bonn. The years in Brazil were productive, especially as the foundation for a monograph, "Lagoa Santa" (1892), a classic in biological plant geography. His tropical experience was amplified by a period in the Danish West Indies. The other extreme of plant life came under his observation during a voyage on the *Fylla* to West Greenland in 1884 and to Northern Finland in 1885. It was Warming who laid the foundation of Arctic geographical botany in a paper in 1887. One of his earlier monographs was "On the Structure, Hibernation, and Renewal of Shoots," read at Stockholm in 1884 and published from Copenhagen in 1891. This is pioneer work on the underground structure of herbaceous perennials and its relation to the mode of hibernation. It is an attempt to group the multiform structures buried in the soil, and those who know Warming's textbook, "Oecology of Plants," will recognise how much of it is concerned with this outlook on plant structure.

During this productive period, Warming led a strenuous life as a teacher, from 1873 to 1882, as Docent in the University of Copenhagen, including lectureships at the Polytechnic, and for pharmaceutical students. In 1882 he was appointed

Professor of Botany at the Technical School, Stockholm, and remained in Sweden till 1886 on his selection as Professor of Botany at the University of Copenhagen and Director of the Botanic Garden. This post he retained till the end of 1911, and during the twenty-five years exerted a profound influence on botany. A Danish obituary notice refers to one aspect: "It may be said that all recent Danish botanists and not a few zoologists are pupils of Warming." Directly, as teacher and investigator, and indirectly through the later researches of his pupils, Eugene Warming has contributed extensively to the knowledge of plant life. In a recent edition of his textbook there are about 2000 titles of papers and monographs referring to plant ecology, and it may safely be said that half of these were inspired or influenced by Warming's work. The best known of his writings is his textbook, originally issued as "*Plantesamfund*," or lectures on plant communities. The value of this was at once recognised, and in 1896 a German edition appeared as the "*Lehrbuch der oekologischen Pflanzengeographie*," or an introduction to the knowledge of plant communities. It was now widely read, and its unique point of view exerted considerable influence on botanical thought. It became an English textbook when Sir I. Bayley Balfour and Professor P. Groom translated it under the title "*Oecology of Plants*" (1909). This edition was fully revised by Professor Warming, and he states that it was almost a new book. In later years he still further revised and extended this textbook, and the last edition was issued from Berlin in 1918, a book of 760 pages with 64 pages of bibliography. The point of view of Warming's outlook on the plant world may be traced to the earlier work of Grisebach, Schouw, Meyen, and Humboldt, each of whom essayed to arrange the vegetation of the world into groups—forests, grasslands, etc.—correlated with environment. So long ago as 1851, the textbook of John Hutton Balfour included groupings of vegetation on these lines. In the latter half of the nineteenth century this kind of botany did not appeal much to the British botanist, nor indeed to Europe as a whole. There were, however, two schools that directed botany on vegetation lines, namely, Professor Ch. Flahault at Montpellier and Professor C. Schröter at Zürich. The former developed the use of maps in connection with

agriculture and forestry, a method later introduced into Scotland by Robert Smith. Schröter and his pupils explored the vegetation of Switzerland, and furnished material for "Pflanzenleben der Alpen" and other monographs.

Warming's outlook on plant life has had a great influence on the work of younger botanists. Robert Smith's work in Scotland was extended throughout Britain, and an earlier British Vegetation Committee became in 1913 the British Ecological Society with its "Journal of Ecology," now one of the leading periodicals on both plant and animal ecology. In America the same influence was evident. F. E. Clements published papers on the vegetation of Nebraska and is now attached to the Carnegie Institute, entirely engaged on ecological problems. H. C. Cowles of Chicago has also contributed to the new ecology directly and through his pupils. Sweden in recent years has become an important centre for the study of vegetation, and the foundation of this work really dates back to the years when Warming was at Stockholm. There could be no greater tribute to Professor Warming's influence than this world-wide reawakening to the importance of studies on the structure of plants in relation to environment.

The chief work of Warming's maturer years was a series of publications on Dansk Plantevækst (Danish vegetation). From time to time appeared "Psammophile Vegetation" (1891), "Halophytstudier" (1897), "Strandvegetation" (1906), "Klitterne" or dunes (1907 to 1909), and "Skovene" or woodlands (1917 to 1919). Each of these is an exhaustive monograph on a special type of vegetation as seen in Denmark, and they include detailed structure and anatomy of the more important plants.

In recent years many honours have been conferred on Professor Warming, including the doctorate degree from Cambridge, Stockholm, Christiania, etc., and honorary membership of numerous societies. As one of the five trustees of the Carlsberg Foundation, Warming had a great opportunity for assisting research and publication by grants from this fund. He assisted actively in organising scientific work in Greenland, Iceland, and the Faeröes, and in the case of the latter islands saw the completion of a large monograph, "The Botany of the Faeröes" (1901 to 1909). Professor Warming had a vigorous personality. During a short period we were under his leader-

ship in Denmark, and knew from experience his keenness, his kindness to the stranger, and his energetic fluent speech available in any one of four languages.

When he retired from the Professorship in 1911, he was still in full vigour, and continued so till last year, when his wife died. At the age of eighty-two he died on 2nd April 1924. In the words of a Danish obituary one may well express his loss: "The Danish Nestor, Professor Eugene Warming, is dead. The news will travel far, for Warming's name was known and revered all over the world."

WILLIAM G. SMITH.

RICHARD GLODE GUYER, Ph.C., M.P.S.

On 21st April 1924 Richard Glode Guyer, Ph.C., M.P.S., a notable personality in Scottish pharmaceutical circles and in scientific societies in Edinburgh, passed away at the early age of fifty-four years. He was elected a Fellow of the Botanical Society in 1921. The youngest son of the late James Brett Guyer, Ph.C., Torquay, he was trained in that high conception of the pharmaceutical profession for which his father was noted. Owing to delicate health he was educated privately, and he served an apprenticeship at Bath. As a student he attended the Pharmaceutical Society's school at Bloomsbury Square, London, where he was deeply impressed by Professor Reynolds Green, whose influence gave a botanical bent to his love of nature study. He qualified as a pharmaceutical chemist in 1894. After a short experience in the laboratory of Messrs. Hodgkinson, Clarke & Ward, London, he came to Messrs. Duncan, Flockhart & Co., Edinburgh, in 1897, and soon rose to be head of their galenical laboratory and organo-therapeutical department. Though never robust, he possessed a tireless energy and enthusiasm, much manipulative skill and ingenuity, an accurate and varied scientific knowledge, and a mastery of detail and methods of organisation. By his tendency to thoroughness and certainty in all his work he was restrained from publication of much valuable information which he had accumulated. In 1921 he contributed an exhaustive treatise on "Cultivation of Medicinal Plants in Scotland—Past and Present" to a meeting of the Pharmaceutical Society in Edinburgh. This treatise, which included much interesting and some new historic information about Botanic Gardens in Edinburgh, is an example of painstaking investigation of ancient archives, and of a distinct faculty for historical research by which he was distinguished. In 1915, during the period of war scarcity of essential drugs, he inaugurated the now well-known Medicinal Herb Garden of Messrs. Duncan, Flockhart & Co. at Warriston, Edinburgh. Practical gardening had been a lifelong hobby, and his skill in horticulture, his botanical and chemical knowledge, and his experience in the manufacture of galenical preparations

for medicinal use, coupled with invincible enthusiasm, combined in enabling him to turn an apparently hopeless piece of waste ground into a flourishing herb garden. A sympathetic and assiduous student of nature in the open country, he was also a highly skilled artistic photographer, and possessed a large collection of exquisite photographs and lantern slides, all prepared by himself. This wealth of material was well illustrated at his last public appearance in February 1924, when he gave a memorable illustrated lecture to a crowded audience of Edinburgh chemists' assistants and apprentices, on "Wild Flowers and their Folk Lore." It was remarked that he had never seemed more fit, and his fascinating address sparkled with vivacious humour. A few days later an old ailment recurred. He underwent a critical operation in a nursing-home and seemed in a fair way to recovery. But again he sickened, another operation became imperative, from which he never rallied, and so he passed away, leaving a widow and two sons, both of whom are medical students. Thus prematurely, as it seems, he departed when his friends hoped he was on the eve of publishing the accumulated material of a busy life of observation and research, and it is to be hoped some at least of this material may yet be made generally available.

J. RUTHERFORD HILL.

TRANSACTIONS
OF THE
BOTANICAL SOCIETY OF EDINBURGH.

SESSION LXXXIX

THE FLORA OF SALISBURY CRAGS.

By G. B. WALLACE, B.Sc.

(Read 20th November 1924.)

The Salisbury Craggs are the western boundary to the hills in the King's Park, which lies immediately east of the City of Edinburgh. The Craggs consist of a volcanic sill and scree, which at the centre are 350 feet in height. The contour is a long curve of three-quarters of a mile, the aspect changing from north-west at the north end to south-west at the southern. The elevation falls gradually southwards, and the sill above the scree varies in height. It is almost entirely vertical, bare Teschenite rock, but a number of plants are established in cracks and where soil has collected, and even dwarfed trees have retained a foothold. The scree surface is rough, sloping at an angle of 30° to 45° ; this is mostly covered with low vegetation, chiefly grasses, but is bare, loose debris in patches.

During the year 1924 a study of the Phanerogamic flora of the Craggs was undertaken, the primary object of which was to observe whether any permanent influence had been made on the flora as a result of an artificial sowing of seeds made there a century before. No complete record of Phanerogamic plants growing on the Salisbury Craggs appears to have been made at any time previous to 1924; even for the King's Park as a whole there is only one list known to the writer (2). The Craggs, however, are given as a locality for individual plants by

various observers, so the available records have been collected, and in the table (pp. 121-124) all the species mentioned are given with an indication of the authority.

The earliest record of Scottish plants is that of Sibbald in 1684. After an interval of over a century appeared Lightfoot's *Flora Scotica* in 1792, and this record contains in an appendix, pp. 1142-1148, "A Catalogue of Plants growing in Edinburgh Park, communicated by Mr. Yalden" (2). The names Edinburgh Park and Queen's Park have been used in the past for what is now called the King's Park.

In 1821 appeared W. J. Hooker's *Flora Scotica* (3); and in January and April of 1824 appeared Greville's *Flora Edinensis* (5) and J. Woodforde's *Catalogue of the Indigenous Phenogamic Plants growing in the Neighbourhood of Edinburgh* (6) respectively. Each writer refers to other early investigations.

The next local flora of Edinburgh is that of Balfour and Sadler in 1863 (8); J. Hutton Balfour also preserved a few records of plants gathered from the Craggs in 1850 (7). To avoid synonymy, Bentham and Hooker's *Handbook of the British Flora* (6th edition, 1892) has been used in correcting older lists.

In the table (pp. 121-124) are given the names of species which are stated to have existed on the Salisbury Craggs, or which exist there now. The list has been compiled from Greville (5), Woodforde (6), the records in an unknown collector's herbarium made in 1833-34, Balfour and Sadler (8), Balfour (7), and from the present writer's observations in 1924. It is a matter of regret that the name of the collector of the plants taken in 1833-34 is unknown. The collection was sold in Edinburgh in 1924 and came into the hands of the present writer. Some 600 species collected almost entirely in the Lothians are represented by specimens mounted and named with extreme care, and form an interesting record of the local flora a century ago. The locality of a find is always given; e.g. "Railway embankment a mile from Edinburgh" was quite sufficiently accurate at that early date, as there is no doubt the "Innocent Railway" was indicated.

In the *Edinburgh Magazine* for the year 1822 (4) is given a "List of [225] Seeds sown on Calton Hill and the foot of Salisbury Craggs"; the influence of this sowing cannot have

been more than temporary since it is not mentioned by Greville nor by Woodforde, who were observant field workers, nor by any later observer.

The introduction to the "List of Seeds sown on Calton Hill and the foot of Salisbury Crags" is interesting. It runs as follows: "It may not perhaps be known except to a few persons, that no sooner were the fine Walks formed round the Calton Hill, and at the bottom of the grand facade of Salisbury Crags, than the utmost pains were taken to introduce Seeds, Plants, and Shrubs, into every corner and crevice (out of the reach of the herd of idle lads, who are so eager to destroy whatever is either useful or ornamental) on these two hills; and as many of them are not natives of the country, they may, in after-time, mislead and puzzle Botanists. We therefore insert the following correct Catalogue of all that have been sown and planted." Botanists may have been "misled and puzzled" subsequently to this planting, but present-day botanists have been spared, for if the plants became established at all, they have become extinct.

The letters G, W, c, S, B, a, placed after the name of a species indicate the authority for the record as follows: G, Greville, 1824; W, Woodforde, 1824; c, a collection made in 1833-34; S, Balfour and Sadler, 1871; B, J. Hutton Balfour, July 1850; and a, the present writer, 1924.

SPECIES RECORDED FROM SALISBURY CRAGS.

		Authority.				
Ranunculaceae	<i>Ranunculus Ficaria</i> , L.	W				
	<i>R. acris</i> , L.	W				
	<i>R. repens</i> , L.	W				
	<i>R. bulbosus</i> , L.	W				
Papaveraceae	<i>Papaver Rhoeas</i> , L.	W				
	<i>P. dubium</i> , L.				S	
Fumariaceae	<i>Fumaria officinalis</i> , L.	W	c	S		
	<i>F. capreolata</i> , L.	W				
Cruciferae	<i>Cheiranthus Cheiri</i> , L.	G	W	S		
	<i>Arabis hirsuta</i> , Br.		W	c		
	<i>A. Thaliana</i> , L.		W			
	<i>Cardamine impatiens</i> , L.			S		
	<i>Hesperis matronalis</i> , L.		W			
	<i>Sisymbrium officinale</i> , Scop.		W			a
	<i>Alliaria officinalis</i> , Andr.		W	c		
	<i>Draba verna</i> , L.		W	S		
	<i>Lepidium sativum</i> , L.			S		

		Authority.					
Resedaceae	<i>Reseda lutea</i> , L.	G	W	S			
	<i>R. alba</i> , L.			S			
Cistaceae	<i>Helianthemum vulgare</i> , Gaertn.			S			a
Violaceae	<i>Viola canina</i> , L.		c	S			a
Polygalaceae	<i>Polygala vulgaris</i> , L.		W				
Caryophyllaceae	<i>Dianthus Armeria</i> , L.			S			
	<i>D. caesiuss</i> , L.			S			
	<i>Silene italica</i> , Pers.		c	S			
	<i>S. Cucubalus</i> , Wibel.			S			
	<i>Lychnis vespertina</i> , Sibth.		W				
	<i>L. Viscaria</i> , L.				B		
	<i>Arenaria verna</i> , L.		W				
	<i>A. serpyllifolia</i> , L.		W	S			a
	<i>Cerastium viscosum</i> , L.		W				a
	<i>Stellaria Holostea</i> , L.		W	c			
Portulacaceae	<i>Montia fontana</i> , L.	G	W	c			
Hypericineae	<i>Hypericum pulchrum</i> , L.			S			
Linaceae	<i>Linum usitatissimum</i> , L.			S			
	<i>L. perenne</i> , L.			S			
Malvaceae	<i>Malva sylvestris</i> , L.		W	S			
Geraniaceae	<i>Geranium sanguineum</i> , L.		W	S			
	<i>G. pratense</i> , L.		W	c			
	<i>G. pyrenaicum</i> , Burm.			c	S		a
	<i>G. Robertianum</i> , L.		W	c			a
	<i>G. molle</i> , L.		W	c			a
	<i>G. columbinum</i> , L.			S			
	<i>Erodium cicutarium</i> , l'Hér.		W				a
Celastraceae	<i>Evonymus europaeus</i> , L.		W	c	S		
Papilionaceae	<i>Ulex europaeus</i> , L.			c			a
	<i>Ononis arvensis</i> , L.			S			
	<i>Medicago lupulina</i> , L.						a
	<i>Trifolium arvense</i> , L.	G	W				
	<i>T. pratense</i> , L.		W				
	<i>T. medium</i> , L.		W				
	<i>T. striatum</i> , L.			S			
	<i>T. repens</i> , L.		W				a
	<i>T. procumbens</i> , L.	G	W				
	<i>T. minus</i> , Relh.		W	S			
	<i>Lotus corniculatus</i> , L.		W				a
	<i>Anthyllis Vulneraria</i> , L.			S			
	<i>Vicia hirsuta</i> , S. F. Gray		W	c	S		
	<i>V. Cracca</i> , L.		W		S		
	<i>V. sylvatica</i> , L.	G	W	c	S		
	<i>V. sepium</i> , L.		W	c	S		
	<i>V. sativa</i> , L.			c	S		
	<i>V. lathyroides</i> , L.			S			
	<i>Lathyrus pratensis</i> , L.			c			a
	<i>L. sylvestris</i> , L.	G	W	c	S		
	<i>L. latifolius</i> , L. (escape from cultivation)				S		
Rosaceae	<i>L. macrorrhizus</i> , Wimm.		W	S			
	<i>Prunus spinosa</i> , L.		W	c	S		a
	<i>Spiraea Filipendula</i> , L.	G	W				a
	<i>Geum urbanum</i> , L.		W				
	<i>Rubus Idaeus</i> , L.		W	c			
	<i>Potentilla anserina</i> , L.		W				
	<i>Agrimonia Eupatoria</i> , L.			c			

		Authority.					
Rosaceae	<i>Rosa luteana</i> , var. <i>dumalis</i> (R. canina, L.)					c	
Crassulaceae	<i>Sedum acre</i> , L.		W			c	a
Saxifragaceae	<i>Saxifraga granulata</i> , L.	G	W				
Umbelliferae	<i>Carum Petroselinum</i> , Benth.		W				a
	<i>Pimpinella Saxifraga</i> , L.	G	W		S		a
	<i>Aethusa Cynapium</i> , L.		W		S		
	<i>Heracleum Sphondylium</i> , L.						a
	<i>Cherophyllum Anthriscus</i> , Lam.		W		S		
	<i>Caucalis nodosa</i> , Sm.	G					
	<i>C. Anthriscus</i> , Huds.		W				
	<i>Daucus Carota</i> , L.	G	W				
	<i>Conium maculatum</i> , L.				S		
Araliaceae	<i>Hedera Helix</i> , L.				S		a
Caprifoliaceae	<i>Sambucus nigra</i> , L.						a
Stellatae	<i>Galium Cruciatum</i> , Scop.		W	c			
	<i>G. verum</i> , L.						a
	<i>G. saxatile</i> , L.						a
	<i>Asperula odorata</i> , L.	G	W	c			
	<i>Sherardia arvensis</i> , L.	G	W				
Valerianeae	<i>Valeriana officinalis</i> , L.	G	W	c			
	<i>Valerianella olitoria</i> , Poll.		W				
Dipsaceae	<i>Scabiosa arvensis</i> , L.	G	W				
Compositae	<i>Bellis perennis</i> , L.						a
	<i>Chrysanthemum Leucanthemum</i> , L.		W				a
	<i>Matricaria inodora</i> , L.		W				
	<i>M. Chamomilla</i> , L.		W				
	<i>Achillea Millefolium</i> , L.		W				a
	<i>Tanacetum vulgare</i> , L.						a
	<i>Senecio vulgaris</i> , L.		W				a
	<i>S. viscosus</i> , L.	G	W		B		a
	<i>Arctium Lappa</i> , L.		W				a
	<i>Carduus lanceolatus</i> , L.						a
	<i>C. arvensis</i> , Curt.						a
	<i>Centaurea nigra</i> , L.		W				
	<i>Tragopogon pratensis</i> , L.	G	W				
	<i>Hypochaeris radicata</i> , L.		W				
	<i>Sonchus oleraceus</i>		W				
	<i>Taraxacum Dens-leonis</i> , Desf.						a
	<i>Crepis virens</i> , L.		W				
	<i>Hieracium Pilosella</i> , L.		W				a
	<i>H. murorum</i> , L.	G	W	c			a
	<i>Cichorium Intybus</i> , L.		W				
Campanulaceae	<i>Campanula rotundifolia</i> , L.		W				a
Primulaceae	<i>Primula veris</i> , L.		W				
Boraginaceae	<i>Echium vulgare</i> , L.	G	W	c	S		a
	<i>Lithospermum arvense</i> , L.		W				
	<i>L. officinale</i> , L.		W				
	<i>Borago officinalis</i> , L.	G	W		S		
Solanaceae	<i>Hyoscyamus niger</i> , L.	G	W		S		
Scrophularineae	<i>Linaria vulgaris</i> , Mill.		W				
	<i>L. repens</i> , Ait.			c	S		
	<i>L. Cymbalaria</i> , Mill.	G			S		
	<i>Veronica officinalis</i> , L.		W				
	<i>V. Chamædrys</i> , L.		W				
	<i>V. hederæfolia</i> , L.			c			
Labiatae	<i>Salvia Verbenaca</i> , L.	G	W	c	S		

		Authority.					
Labiateae .	<i>Thymus Serpyllum</i> , L.						a
	<i>Calamintha Acinos</i> , Clairv.				S		
	<i>C. Clinopodium</i> , Benth.	G	W				
	<i>Nepeta Glechoma</i> , Benth.		W				
	<i>Teucrium Scorodonia</i> , L.		W				a
Plantagineae .	<i>Plantago major</i> , L.						a
	<i>P. lanceolata</i> , L.						a
Polygonaceae .	<i>Rumex crispus</i> , L.			c			a
	<i>R. Acetosella</i> , L.						a
Chenopodiaceae	<i>Atriplex patula</i> , L.		W				
	<i>A. hastata</i> , L.		W		S		
Euphorbiaceae	<i>Mercurialis perennis</i> , L.		W				
Urticaceae .	<i>Urtica urens</i> , L.		W				
	<i>U. dioica</i> , L.		W				a
Aroideae .	<i>Arum maculatum</i>					B	
Orchidaceae .	<i>Orchis mascula</i> , L.		W				
Liliaceae .	<i>Scilla nutans</i> , Sm.	G	W				
	<i>Allium vineale</i> , L.	G	W	c	S	B	
Cyperaceae .	<i>Carex praecox</i> , Jacq.		W				
Gramineae .	<i>Anihoanthum odoratum</i> , L.			c			a
	<i>Phleum pratense</i> , L.						a
	<i>Alopecurus pratensis</i> , L.			c			a
	<i>Agrostis alba</i> , L.						a
	<i>Aira caespitosa</i> , L.						a
	<i>A. flexuosa</i> , L.						a
	<i>A. praecox</i> , L.	G	W		S		a
	<i>A. caryophyllea</i> , L.	G	W		S		a
	<i>Avena pratensis</i> , L.	G	W	c	S		a
	<i>A. pratensis</i> , var. <i>pubescens</i> , Huds.		W				
	<i>A. flavescens</i> , L.	G	W	c			a
	<i>Arrhenatherum avenaceum</i> , Beauv.		W				a
	<i>Nardus stricta</i> , L.						a
	<i>Hordeum pratense</i> , Huds.	G	W				
	<i>H. murinum</i> , L.		W				a
	<i>Agropyrum repens</i> , Beauv.		W				
	<i>Lolium perenne</i> , L.						a
	<i>Bromus erectus</i> , Huds.	G	W				
	<i>B. sterilis</i> , L.			c			
	<i>B. mollis</i> , L.		W	c			a
	<i>Festuca ovina</i> , L.			c	S		a
	<i>F. elatior</i> , L.	G					a
	<i>Dactylis glomerata</i> , L.		W				a
	<i>Cynosurus cristatus</i> , L.			c			a
	<i>Briza media</i> , L.						a
	<i>Poa rigida</i> , L.	G	W				
	<i>P. annua</i> , L.						a
	<i>P. compressa</i> , L.	G	W				
	<i>Molinia caerulea</i> , Moench.						a
	<i>Koeleria cristata</i> , Pers.	G	W	c	S		a
Totals		38	115	43	55	4	68
Total number of species						178	

All species referred to Salisbury Craggs by any of the six authorities mentioned at the head of the table are recorded here together for comparison. The totals of the various lists vary considerably. Only the 1824 list of Woodforde and the 1924 list of the present writer can be considered anything like complete. Yet the totals of these two lists vary considerably, being 115 compared with 68. Altogether there are 156 species recorded by the five earlier authorities, and of these 133 were recorded by the first three, ninety years ago.

There has thus been a great diminution in the number of species represented on the Craggs during the past century. Twenty-two species observed on the Craggs in 1924 had not previously been recorded from that locality; some of these have, however, been recorded from the King's Park as a whole, or are known to have been common in the district round Edinburgh a century ago.

The most striking changes in the flora have occurred in the Cruciferae, Caryophyllaceae, and Papilionaceae. In these three families the total number of species in the records previous to 1924 is 40, while the total in that year is 8. Least diminution in numbers has occurred in the Compositae and Gramineae, which, from constituting less than one-quarter of the flora previous to 1924, now represent more than one-half.

Judging from the natural habitats of the various species in the table, there appears to be no striking change in the ecological character of the flora during the past century. The vegetation is what one would expect on dry rocky ground and on fairly dry hill pasture. Some of the plants, taken at the foot of the scree where it merges into the rough pasture of the level ground, are not found higher up. *Montia fontana*, and to a lesser degree other species in the earlier flora, would suggest moister conditions than those prevailing at present.

We may consider briefly the changes, temporary or permanent, in the environment which might account for the great diminution in the number of species recorded on the Craggs since 1824. The exposed nature of the Craggs, and the accessibility of all but the vertical faces of the sill, allow of the human element destroying conspicuous or rare species. This might account for such a species as *Hyoscyamus niger*, which was no doubt a stray and rare, disappearing. The presence of sheep on the scree would account for the disappearance of

certain plants. As regards the accessibility of the Craggs, in the Magazine of the Scottish Geographical Society for the year 1919 are reproduced some old maps. Those made in 1780, 1804, 1825, and 1852 give a good indication of the increase in the size of Edinburgh, with its spread to the edge of the King's Park. This closer contiguity of the city has meant a greater menace to the flora; also the smoke from the city, the prevailing wind being from the west, must have become an increasingly detrimental factor. From the maps referred to it would seem that in 1780 and 1825 the land between the Craggs and the city was fenced, but that in 1852 fences no longer existed; while paths are represented on the last map much as they are to-day. It is just over one hundred years since the Radical Road was cut between the sill and the scree, and prior to 1852 some quarrying was done on the sill.

It is hardly likely that the earlier collectors set out to make a complete survey of the flora of Salisbury Craggs, but when their lists are combined it is probable that a substantially complete record is obtained; while the 1924 survey was as complete as possible. There is thus ground for the conclusion that, from having a comparatively large and varied flora a century ago, the Craggs have now a much smaller flora, composed largely of composites and grasses.

The thanks of the writer are due to Mr. W. E. Evans and to Mr. J. R. Matthews of the Royal Botanic Garden, Edinburgh, for assistance in the determination of species.

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- HERBARIUM.—Collection from Environment of Edinburgh, 1833-34, at Royal Botanic Garden, Edinburgh.

NOTES ON BRITISH CARICES. By ARTHUR BENNETT, A.L.S.

(Read 18th December 1924.)

Carex Davalliana, Sm.—Doubts were expressed for many years whether this really had occurred in Britain. The only true specimens were those gathered by Mr. Groult and Mr. Ward at Lansdown, Bath. There are specimens in the British Museum, in the herbarium of York Phil. Society!, and in Mr. Spencer Bickham's herbarium!

C. pulicaris var. *montana*, Pugs., in Journ. Bot., vol. lix (1921), p. 106.—This quite simulates *C. rupestris*, All., and specimens were gathered for it by a well-known botanist.

C. aquatilis, Wahl. var. *rigida*, Ar. Benn., in Ann. Scot. Nat. Hist., 1910, p. 236.—Among 100 specimens of *C. aquatilis* from Scotland, Ireland, and Wales in my collection not one resembles this remarkable variety, and there was nothing like it in the splendid series of Scandinavian specimens in Dr. Almquist's herbarium. In fact, it is more like a *salina* plant or, in facies, a rare Portuguese species, *C. fasciculata*, Link.

The latest addition to the area of *C. aquatilis* is Cumberland (C. E. Salmon, 1919). It is still a remarkable fact that although the isothermal lines rise on approaching Great Britain, yet *C. aquatilis* extends farther south than anywhere else in Europe in Wales at 52° 30' N. Lat., while 58° in Svealand, Sweden, is its next southern record.

C. spiculosa, Fr. var. *hebridensis*, Ar. Benn., in Journ. Bot., vol. xxv (1897), p. 252.—No further light has been thrown on this curious plant. Dr. Almquist agreed that Fries' plant was the only one to which it could be referred, differing only in the want of the scabrid glumes, although they are equally as long. Fries' species is one of the rarest of carices, known only from the shores of the White Sea in Russian Lapland.

C. panicea, Linn. var. *intermedia*, Mieg. & Moench.—Scotland, near Fort William (Rev. E. S. Marshall).

C. discolor, Nylander, Spic. Fl. Fenn. (1846); *C. epigeios*, Fr. (*non* Laest.).

In the Journal of Botany, vol. xxxv (1897), p. 251, I mentioned finding three specimens of this: one in Kew herbarium,

one in the Boswell Syme herbarium, and one sent me by Dr. Buchanan White from Caenlochan, Forfar, who labelled it "the Alpine form of *C. aquatilis*." I have not been able to find any other specimens, although the late Mr. Barclay went through the Perth herbarium for me, and, strange to say, there is not another specimen from Caenlochan. I sent my specimen to Dr. Almquist, suggesting the names *C. aquatilis* var. *epigeios*, Fr. non Laest., or *C. rigida* var. *inferalpina*, Laest., who replied: "Certainly to be brought to the former, leaves very like the latter." Nyman, Richter, Hjelt, and Almquist all agree in referring Fries' *epigeios* to a form of *C. salina*.

C. flacca, Schreb.—It seems we must again change the name of this to *C. diversicolor*, Crantz (1766). (*C. flacca* (1771), *C. glauca*, Scop. (1772), and *C. recurva*, Huds. (1778).) Crantz's name is given by Lindman in *Svensk Fanerogam. Fl.*, 1918, p. 141. Neither Richter nor Asch. and Graeb., *Syn. Fl. Mit. Eur.*, 1902, p. 134, name it.

C. Oederi var. *cyperoides*, Marss., *Fl. Neu Vorpommern*, 1869, p. 539.—This is the small variety with the spikes all conjoined at the apex of the peduncle.

C. flava, Linn. \times *saxatilis*, Linn. = \times *C. Marshalli*, Ar. Benn.—For years I have had this *Carex* before me, but failed to find any reference to it in any flora. So long ago as 1878, Mr. H. C. Watson wrote me: "I know the *Carex* enclosed better by sight than by name. Specimens have been in my herbarium thirty to forty years, yet never confidently determined, one of them sent by Dr. Balfour, now Professor of Botany in Edinburgh University, who labelled it *saxatilis*, which it is not." The heads are like some form of *C. saxatilis*, Linn. (*pulla*, Good.), except for colour, which is greenish suffused with reddish-brown. I have it from Argyll (Druce, who suggested a hybrid), Perth (Marshall), Forfar, Aberdeen, and W. Ross.

C. inflata var. *borealis*, Laest., in *Loca Parell. Pl.*, 1839, p. 223.—"Easily known even when barren by its long involute leaves, and is a plant of the saddle-backs from 750 m. upwards, if water is constant." See Ewing in *Ann. Scot. Nat. Hist.*, 1910, p. 176.

C. inflata var. *utriculata*, Kuk., *C. utriculata*, Boott, *C. rhynchophysa*, Ar. Benn. non Meyer, *Journ. Bot.*, vol. xxxi, 1893, p. 33.—This is the Irish plant I wrongly referred to

Meyer's species. But Bailey, in Mem. Torrey Bot. Club, vol. i, 1889, p. 59, considers it a distinct species from *C. rostrata*, Stokes, i.e. *C. inflata*, Huds. On the other hand, Kükenthal makes it a variety. *Carex ampullacea* var. *robusta*, Sonder (1851), var. *elatior*, Blytt (1861), and var. *latifolia*, Asch. (1864), all represent large forms of the species, but are not the same as Boott's plant.

C. saxatilis, Linn. var. *glomerata*, Ewing, in Ann. Scot. Nat. Hist., 1910, p. 180.—This is very like small plants of *C. atrata*, Linn., and grows on Ben Lawers, Creag Mhor, Glen Lochay, and Beinn Heasgarnich.

ON *Codium mucronatum*, J. AG. VAR. ATLANTICUM.

By ROBERT MOYES ADAM. (With Pls. VI-VII.)

(Read 15th January 1925.)

In bringing before the notice of the Society *Codium mucronatum* var. *atlanticum*, let me confess at the outset that my matter is nothing new. I am only venturing, indeed, to bring to light some interesting notes gleaned largely from elsewhere.

Our knowledge of algal distribution is far from complete, and much helpful information is needed before we can be precise as to areas where many of our marine algae are to be found. Information from north-west Scotland is urgently sought.

Codium mucronatum, a noteworthy example of an alga which has only recently been recognised on the British coast, has existed there for upwards of a hundred years—yet as a species distinct from the widely distributed *Codium tomentosum* it was not firmly established until 1910. A brief reference to the history of the alga is therefore of some interest.

Codium mucronatum as a species was first described by Agardh in 1880. From the plants he examined, and upon which he founded the species, he distinguished three varieties:

Var. *tasmanicum*—having its home on the coasts of east and south-east Australia.

Var. *Novae Zelandiae*—from the coasts of New Zealand.

Var. *californicum*—coasts of California.

In 1910 var. *atlanticum*, a further variety, was recognised, being first described by Mr. A. D. Cotton in his exhaustive account and study of the Marine Algae collected in the course of the Clare Island Survey during the years 1909–1911, and published in the special volumes on that area by the Royal Dublin Society. In this account Mr. Cotton was the first to recognise as forms of *Codium mucronatum* plants formerly assumed to be *Codium tomentosum*.

At first there seems to have been some doubt as to this plant's affinity with *mucronatum*, which, as has been stated, was named by Agardh from material growing in Australian waters. Further investigation, however, revealed that, of the

described varieties of this species, the Tasmanian was more distinct from the New Zealand variety than was the Irish plant from the latter. Now the question as to how so remarkable a plant escaped the veteran algologist Harvey and others is a puzzle, although it seems that the late Mr. Batters, in his work among the algae of West Ireland, had determined a plant from Kilkee in 1897 as *Codium elongatum*. This material and the locality were re-examined by Mr. Cotton and fresh light was thrown upon this mysterious and single record of *Codium elongatum* from British waters. Batters' plant was rediscovered and without difficulty determined to be the new variety *atlanticum* of *Codium mucronatum*.

Investigation of numerous collections and herbarium material in existence shows that *Codium mucronatum* till 1910 was unrecorded for Europe, and is, as far as is known, confined to several localities in the west of Ireland, the north-western corner of the same island, the Isle of Man, the shores of Scotland in Ayrshire, Bute, Argyllshire—seaboard on the west of Mull, Outer Hebrides, and the Orkneys: and, what is more remarkable, its apparent absence from the shores of England, from whence there is as yet no record of the plant.

Outside Europe the plant is recorded from South Africa, Japan, Cape Horn, with of course the region of Australia, Tasmania, and New Zealand, and California; and recently examination was made of a plant gathered in Sitka Sound on the extreme north-west shores of North America with all the characters of the variety *californicum*.

Agardh's conclusions regarding this plant were that all varieties belonged to one species, the varieties being distinguished by the degree of mucronation of the utricles. Cotton suggests that the degree of mucronation varies with the vigour of the plant's growth.

The habitat and the field characters of this plant are good clues to its identity. It is fond of growing in sunny rock pools, and not infrequently at half-tide levels, occurring usually as isolated plants. When growing submerged in sunny rock pools the alga takes on a light green colour—a partial optical effect produced by the presence of air bubbles or oxygen discharged during active photosynthesis in sunlight and lodging between the utricles—but at low-tide levels is a dark green. This characteristic dark-green hue of plants

growing in deep water and in partial shade was very apparent in a specimen collected at half-tide level on the foreshore near Gribun, on the west side of the Island of Mull near the entrance to Loch-na-Keal.

If fresh material of the two *Codium*s be placed side by side for comparison, a more robust habit is observable in plants of *Codium mucronatum*. There is also a marked tendency to irregular branching, while a decided roundness in the shape of the thallus at the junction of the branches with the main frond assist to mark this alga as quite distinct.

In plants of *Codium tomentosum* it is noticeable that the fronds are more slender. The branching is regular and dichotomous, with a decided flattening where the thallus divides; young plants show this feature to a marked degree.

As to the habitat of this plant, the Gribun specimen was growing attached to the surface of a coarse and gritty sandstone, on one side shaded by the large thalli and masses of *Fucus serratus*. Indeed, so well hidden was the *Codium* that it required considerable force to push aside the *Fucus*. On the off side the *Codium* had no interference from *Fucus*, the rock surface in close proximity having a dense growth of *Dictyota dichotoma* var. *multifrons*, *Ahfeldtia plicata*, *Leathesia difformis*, and encrustations of *Lithothamnion* spp. A further habitat examined—this time on the Island of Ulva—was a series of sunny rock pools on the summit of a causeway formed by the ends of basaltic columns, and at the level of high-water mark. These pools at many states of the tide received all their fresh supplies of sea-water from spray cast up by the breaking seas, which are a constant feature of this part of the coast. The rock pools, which did not measure a depth of more than 12 inches or slightly more, had as companion plants to the *Codium*, *Stylophora rhizodes* and a few sporelings of *Ulva* and *Enteromorpha*. On the shores of the Outer Hebrides where specimens of this alga have been examined they were found growing at the margin of the Laminarian zone attached to a slab of gneissic rock which had a surface drained dry at low water, and had as companion plants *Himanthalia lorea*, *Laminaria saccharina*, with an occasional *Fucus serratus*, but, generally speaking, other algae were conspicuous by their absence. It was in such a habitat that the largest specimen yet observed of *Codium mucronatum* var. *atlanticum* was

growing. Measurements taken of this plant indicated a thallus expansion exceeding 30 inches, and a photograph taken after the plant was submerged by the incoming tide conveys even better the impression of what was truly a magnificent plant (Plate VI).

Any doubts as to the identity of *mucronatum* and *tomentosum* vanish when preparations of each species are put side by side.

In *tomentosum*, besides the much more slender fronds, which are much branched, 3–4 mm. thick, often slightly flattened at the axils, dichotomously branched, with surface very tomentose but becoming smooth with age, the following microscopic characters are diagnostic:—*Utricles* cylindrical, small, 500–650 μ long \times 120–170 μ , rarely 220 μ wide, apex distinctly thickened, blunt, the smaller utricles sometimes pointed but never mucronate (Plate VII, fig. 2). Female gametangia small, somewhat pear-shaped, often 200–250 μ long \times 40–70 μ wide (Plate VII, fig. 3). Gametes 20–22 μ long \times 10–12 μ wide.

In *mucronatum* var. *atlanticum* the plants are more robust, averaging in size 6–9 inches long, sometimes attaining 30 inches and much branched from below. Colour a deep green when shaded, but a light green when growing in shallow water exposed to bright sun. Fronds 5–7 mm. thick, entirely cylindrical, not so flattened below the axils, dichotomous, or dichotomously fastigiate, surface smooth or slightly tomentose when young. *Utricles* comparatively large, cylindrical or slightly clavate, 800–1000 μ long \times 250–300 μ wide, apex thin-walled, surmounted in the younger parts of the fronds by a small, sharp, or blunt mucro, which in the older parts is often absent (Plate VII, fig. 4). Female gametangia large, 300–400 μ long \times 80–120 μ wide (Plate VII, fig. 5).

The species of *Codia* in question are not satisfactory plants to deal with for purposes of comparison after drying. Specimens are best preserved in a solution of formalin 2–3 per cent. As to the season for collecting the plants, *Codium mucronatum* seems to reach its maximum size in summer, while *tomentosum* attains its greatest dimensions in winter.

REFERENCE.

- A. D. COTTON: Proceedings of the Royal Irish Academy, vol. xxxi, Section I.

EXPLANATION OF PLATES.

- Fig. 1. *Codium mucronatum* var. *atlanticum* in natural habitat, rock pool at Orosay Point, south-east corner of Barra, Outer Hebrides. One-sixth natural size.
- Fig. 2. Transverse section of thallus of *Codium tomentosum*, showing interwoven mass of filaments bearing utricles, some with gametangia. $\times 30$.
- Fig. 3. A single utricle of *C. tomentosum*, with gametangium. $\times 72$.
- Fig. 4. Transverse section of thallus of *Codium mucronatum* var. *atlanticum*, with interwoven filaments bearing characteristic utricles. $\times 30$.
- Fig. 5. A single utricle of *mucronatum* var. *atlanticum*, with two gametangia. $\times 72$.



FIG. 1.—*Codium mucronatum*, Agardh, var. *atlanticum*.

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FIG. 2.

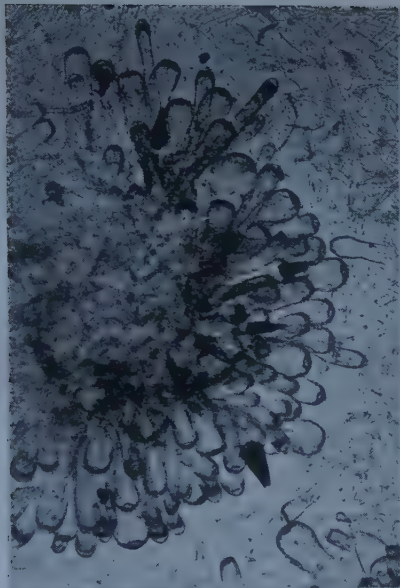


FIG. 4.



FIG. 3.

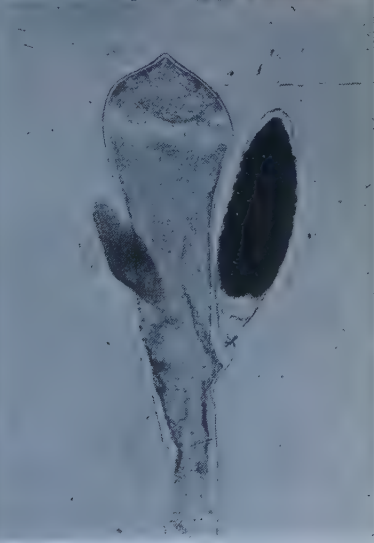


FIG. 5.

NOTES ON A DIATOMACEOUS DEPOSIT AT DALMAHOY, EDINBURGH. By ELLEN B. HENDERSON, B.Sc. (With Pls. VIII-IX.)

(Read 21st May 1925.)

In the autumn of 1924 Mr. J. W. Lunn discovered a bed of diatomite near Dalmahoy, Edinburgh. Samples of this material were sent to Mr. George West of University College, Dundee, for inspection and report. This gentleman, finding that the samples contained interesting matter for investigation, handed the material to me to report upon as a part of my work in preparation for the Honours Science Examination in Botany, and under his direction the investigation of the samples and the report thereon has been prepared.

The crude material, as obtained from the deposit, was white and powdery; it was also remarkably clean, and would answer the purpose of diatomite for many industrial purposes without any cleaning process. When a little of it was shaken up with distilled water the diatoms were for the most part immediately separated, and the water at once had a milky appearance; there were, however, minute clusters of diatoms which quickly fell to the bottom of the tube in which the material was shaken up with the water. These small lumps appeared to consist of fragments and more or less complete specimens held together by a semi-clear quartz-like substance which was not attacked by any of the following acids at boiling-point—hydrochloric, nitric, and sulphuric; but appeared somewhat loosened by treatment with strong liquid ammonia. This cementing material, present in extremely small quantity, was not specially investigated, but it may be calcium sulphate. In the dolerite adjacent to the deposit of diatomite there is (as exhibited in several microscopical sections of this rock kindly shown me by Mr. West) an abundance of Labradorite and Augite, both of which contain calcium; this being liberated by disintegration of the rock, and finding its way to the diatomite, might combine with sulphur from the organic matter and form the cementing substance.

A casual examination with the microscope demonstrated

that the diatoms in this deposit were very fragmentary, and comprised a remarkably small number of species, the dominant forms being common members of the genera *Pinnularia* and *Cymbella*. There was a noticeable absence of sand, lime, and organic matter. All the diatoms were more or less eroded, even the most perfect specimen presented the appearance of being overtreated with a strong alkali, similar to cases where this agent has to be employed in the breaking down of certain diatomaceous rock in order to liberate the specimens. Complete examples of the valves of any species are comparatively scarce in this deposit, but, owing to the small number of species, all the larger fragments could readily be traced to their origin. This diatomite is further remarkable for the relative abundance of minute siliceous *Chrysomonadineae*. Mr. West informs me that he has not hitherto found these tiny organisms so abundant either in species or in individuals in any similar deposits that he has examined, and, if only on this account, he considers this deposit a most interesting one. Very little is known regarding these minute organisms, of which some seem to have been discovered by Ehrenberg and announced in his *Mikrogeologie* and other works. Mr. West informs me that he has seldom seen any of these organisms in the living state, nor does he know of any British observer who has any personal acquaintance with them in life. This he attributes to such small fry passing through the meshes of the ordinary fine silk collecting net, and he suggests the use of a collecting bottle and centrifuge instead of the net as a means of obtaining these forms in the living state. The erosion of the diatoms, which is so conspicuous a feature of the deposit, is naturally more evident in the case of the porous valves than with the more solidly constructed girdles, which, in the case of some of the large species, remain more or less intact, and these thus form another conspicuous feature of this diatomite.

The abundance of certain species of *Pinnularia* and *Cymbella*, all of which are inhabitants of bogs, tarns, and other quiet waters, and the scarcity of forms that commonly live in streams, together with the absence of sand and other impurities, both inorganic and organic, seems to indicate that the deposit had accumulated in water of such depth as to inhibit the growth of a copious phanerogamic flora, and that the affluent was of

small dimensions, probably a mere trickling stream; or possibly the water-supply was from springs.

Comparing this deposit with that of some others in Scotland (say, for instance, that from Black Moss, Dinnet, Aberdeenshire), one is struck by the remarkable paucity of species at Dalmahoy and by the purity, as previously remarked upon. At Black Moss the diatomite is mostly in the form of a fine-grained peat, the organic substance of which has been due to the exuberant growth of aquatic and marsh plants, the remains of which were deposited simultaneously with the diatoms. Mr. West also informs me that a comparison of the Black Moss deposit with that now going on at the bottom of the adjacent Loch Kinnord is of great interest, and he recommends these sites to the attention of geologists as an interesting subject of investigation. Loch Kinnord is an extensive but shallow lake with an average depth of 3 feet to 12 feet; the bottom, therefore, is well within the photic zone and is nearly everywhere covered with vegetation, the Characeae being very abundant. The affluent meanders through a zone of reeds wherein it drops most of its coarser sand, so that very little of this is found in the bottom mud of the lake, the water of which is peaty. The bottom of this lake is mostly covered with an olive-brown non-foetid mud, from a few inches to a foot or so deep, and this consists chiefly of vegetable matter in stages of decomposition; mixed with it is an abundance of diatoms, such as species of *Pinnularia*, *Surirella*, etc. In some parts of the lake this mud is comparatively bare, but in many places it is carpeted with such plants as *Nitella translucens* and *Isoetes lacustris*, or *Littorella lacustris*, etc. Below this mud there is a similar layer, but brown in colour and becoming paler downwards. Below this again there is a thin whitey-brown layer, composed chiefly of diatoms and forming in fact a diatom ooze. A fourth layer about a foot thick is of a deep orange colour, consisting of diatoms and flocculent matter, doubtless some form of iron oxide. Lower down there is a fifth layer of a pale green hue consisting of diatoms and of fine flocculent matter, probably some form of ferrous sulphate. A lump of this substance laid on a board in the bottom of the boat to drain lost its colour and assumed a dark olive tint in about two hours, but when the lump was broken the fresh surface thus exposed was again green, but paler than when

first hauled up. This rapid change of colour was probably due to ferrous sulphate having been oxidised to ferric sulphate on contact with the atmosphere. It may be supposed that the ferric substances sinking downwards from the white layer, from which they had been liberated by the complete disintegration of the organic matter, had sunk through the lower layers, the oxide being retained in a distinct layer of the diatoms above the sulphate which formed in the fifth layer. These observations were made on a very windy afternoon when the management of the boat occupied a considerable portion of the observer's attention, and he has not since been able to revisit the spot. The layers referred to were found most distinctly arranged and coloured at the western side of the loch, between the Island and the Vat burn. It may further be remarked that the lower layers mentioned contained a greater proportion of boreal forms of Diatomaceae than the upper layers, and a similar feature was observed in the lower beds of the adjoining Black Moss diatomite. It would seem reasonable to suppose that the bottom layers of diatomaceous material in both sites mentioned were formed soon after the last glacial period, and that the original Black Moss Loch, being shallower than the existing lochs of Kinnord and Ordie, became filled up by the growth of diatoms, aquatic, and marsh flowering plants, etc., more quickly than the deeper waters; the wearing down of the natural outlet being a further matter for consideration on this point.

The samples of Dalmahoy diatomite were prepared for microscopical investigation in the following manner: An egg-spoonful of the material was vigorously shaken with half a pint of distilled water in a strong tube and graded into heavy, medium, and light parts by elutriation. These grades were each successively treated by boiling—first, with hydrochloric acid to destroy calcareous matter; second, with boiling nitric acid to break up further the material and disintegrate organic substances; third, with boiling sulphuric acid to which, after boiling for some minutes, potassium chlorate was added very cautiously and repeatedly till all evidence of organic matter had disappeared and the liquid became of a pale yellow colour. After each acid treatment two or three washings in distilled water were employed to get rid of the acid, care in each instance being taken to allow ample time, say twenty-four hours, for

the diatoms to settle. After the sulphuric and potassium chlorate all trace of acid was removed by repeated washing and settling. Finally, the specimens thus liberated from sand, lime, organic matter, etc., were vigorously shaken up for a few minutes with a small quantity of liquid ammonia in a wide tube. This was quickly reduced in strength by adding four or five times its bulk of distilled water, and immediately the specimens had sunk to the bottom of the wide tube the ammonia water was poured off and fresh distilled water added. Each of the three graded and cleaned samples was then again graded in the same way in distilled water, and subsequently bottled in the same fluid. For keeping, 50 per cent. alcohol is employed to prevent growth of Fungi, but this must be replaced by distilled water at the time of mounting or specimens will not spread properly over the cover-glass; the spirit evaporates too quickly, and the diatoms dry in waves. Microscopical slides were prepared by vigorously shaking a bottle of cleaned material and spreading a small drop of the fluid over a thin cover-glass, which was then set aside for twenty-four hours under cover to dry spontaneously. By this means the diatoms spread nicely and adhere to the cover-glass. A small drop of prepared styrax in benzole is now placed on each cover-glass, which is again set aside under cover for the medium to spread and its solvent to evaporate. On the next day the prepared cover-glasses are gently lowered to the centre of a slide, which is then placed on a hot plate. The gentle heat dissolves the stiff styrax, causing it to spread evenly under the cover. The slide is then put in a warm place for a few days to dry, when it is ready for the microscope. Microscopical examination is conducted systematically by means of a mechanical stage, and a power of about 130 diameters supplemented by one of 500 diameters, specimens for further observation being recorded by means of the Maltwood finder; oil immersion objectives giving 1000 to 1500 diameters being subsequently used where necessary. If chloroform is employed as the solvent for the dried styrax, carbonyl chloride (COCl_2) is apt to develop in the mount on exposure to daylight, and this chemical will destroy the diatoms in the course of two or three years, as experienced by Mr. West and Mr. David M'Call.

The small variety of species in this diatomite is a remarkable

feature in view of the large numbers of forms usually found in such deposits. As no new forms have been found, illustrations of the species and varieties are unnecessary for this paper, but references to the best-known literature are appended to each of the forms described.

The following is a list of species and varieties found on about sixty preparations made and examined according to the methods described :—

1. *Pinnularia streptoraphe*, Cl. : Cl., Syn., ii, p. 93 ; A. S., Atl., xlii, fig. 7. Grun., Franz-Jos. L.D., p. 98, pl. i, fig. 22.

A large form with parallel margins, almost transverse striae, and a strongly complex raphe. This is not one of the most common forms of *Pinnularia*, but large and beautiful specimens of it abound in this deposit.

2. *P. viridis* and its vars., Nitzsch : Cl., Syn., ii, p. 91 ; A. S., Atl., xlii, figs. 11–14, etc. ; V. H., Syn., p. 73, pl. v, fig. 5.

Not abundant, and as the specimens are mostly eroded identification with the numerous named forms of this species is impossible.

3. *P. nobilis*, Ehb. : Cl., Syn., ii, p. 92 ; Donk., B.D., p. 68, pl. xi, fig. 1 ; V. H., Syn., p. 73, pl. v, fig. 2 ; A. S., Atl., xliii, fig. 1 ; W. Sm., B.D., i, p. 54, pl. xvii, fig. 161.

4. *P. alpina*, W. Sm. : W. Sm., B.D., i, p. 55, pl. xviii, fig. 168 ; Cl., Syn., ii, p. 81 ; Donk., B.D., p. 27, pl. iv, fig. 6 ; A. S., Atl., xlv, figs. 1–4.

Of all the species which occur in the deposit, *P. alpina* is especially noted for the size and beauty of the specimens.

5. *P. Dactylus*, Ehb. : (*P. Gigas*, Ehb.) Am., p. 133, Taf. ii, 3, fig. 1 ; Cl., Syn., ii, p. 90 ; A. S., Atl., xlii, figs. 3, 4, 6 ; V. H., Syn., pl. v, fig. 1.

6. *P. major*, Kutz : Cl., Syn., ii, p. 89 ; Donk., B.D., p. 69, pl. xi, fig. 2 ; V. H., Syn., p. 73, pl. v, figs. 3, 4 ; A. S., Atl., xlii, fig. 8.

7. *Cymbella aspera*, Ehb. : Ehb., Mik., Taf. v, 1, fig. 1 (*C. gastroides*, Kutz) ; Cl., Syn., i, p. 175 ; A. S., Atl., ix, figs. 1, 2 ; x, fig. 7 ; V. H., Syn., p. 63, pl. ii, fig. 8 ; Grun., Franz-Jos. L.D., p. 97 (45), pl. i, fig. 7.

This species is one of the commonest forms found in the Kieselguhr. The valves of this diatom are here usually more complete than those of any other species in the collection; the polar nodules very often have been damaged, but the majority of the specimens show very little erosion. This is due to the fact that the valves of this species of *Cymbella* are more strongly silicified than those of the other diatoms occurring in the deposit, and therefore they were better able to withstand the erosive action of the alkali. *C. aspera* is a large form, and is one which inhabits lakes and still waters in contradistinction to many of the species of this genus which are stream forms, and often live in the fastest flowing water attached to stones.

8. *C. lanceolata*, Ehb: Ehb., Inf., p. 224, Taf. xix, fig. 6; Cl., Syn., i, p. 174; A. S., Atl., x, figs. 8-10; V. H., Syn., p. 63, pl. ii, fig. 7.

This form is rare in the deposit, and has been observed only as fragments.

9. *Stauroneis Phoenicenteron*, Ehb., *forma*: Ehb., Am., Taf. ii, 5, fig. 1; V. H., Syn., p. 67, pl. iv, fig. 2, for type.

This diatom is of very common occurrence in the deposit, but the specimens for the most part have the striae much disintegrated, and the strongly silicified central and axial areas, minus the delicate striae, abound. There are comparatively few complete specimens observable in the preparations, and the majority of these are frustules, which are unsuitable for high powers owing to the illuminating cone being scattered by the punctae on the lower valve. The specimens are a medium-size, sub-rostrate form of this variable species, much resembling a coarse *S. anceps*. The stauros is widened towards the margin and the striae are very distinctly radiate. An average specimen is $120 \times 26 \mu$, striae 13 and punctae 15 in 10μ , axial area at $\frac{1}{3}$ its length, 5μ wide.

10. *Hantzchia amphioxys*, Grun. (*Nitzschia*, W. Sm.): V. H., Syn., pl. lvi, figs. 1 and 2.

This is a rare species in the diatomite.

The genus *Eunotia* is fairly well represented in this deposit as regards numbers of species, but the specimens being small

and greatly disintegrated are consequently difficult to identify, but the following species have been recognised :—

11. *Eunotia diodon*, Ehb. : V. H., Syn., pl. xxxiii, figs. 5, 6, 7 ;
Wolle, D.N.A., pl. xxxvi, figs. 5, 6, 21, 22.
12. *E. gracilis*, Ehb. : V. H., Syn., pl. xxxiii, figs. 1, 2.
13. *E. robusta*, Ehb. : V. H., Syn., pl. xxxiii, figs. 11–13 ;
Wolle, D.N.A., pl. xxxvi, figs. 9–13.
14. *E. monodon*, Ehb. : V. H., Syn., pl. xxxiii, figs. 3, 4 ;
Wolle, D.N.A., pl. xxxvi, figs. 4, 12.
15. *E. praerupta*, Ehb. : V. H., Syn., pl. xxxiv, figs. 17–26 ;
Wolle, D.N.A., pl. xxxviii, figs. 5, 6.
16. *E. pectinalis*, Kutz : V. H., Syn., pl. xxxiii, figs. 17–21 ;
Wolle, D.N.A., pl. xxxvi, figs. 15–20 ; pl. xxxviii, figs.
12, 15.

A small species of *Gomphonema* is of rare occurrence in the deposit, but being disintegrated cannot be exactly identified.

Besides the minute *Chrysomonadineae* mentioned previously (p. 136), there are very small forms of *Cyclotella* and *Melosira* present in the diatomite. All these remains are eroded, and need careful study with the highest powers before they can be identified, and as none of them occur in abundance, the finding of good specimens is a matter of time ; on this account they have not been recorded.

The remains of the *Chrysomonadineae* seem to be chiefly their endogeneously produced resting-cysts. These have smooth or ornamented siliceous shells of spherical or elliptical form, each provided with a pore which in life was probably closed by a stopper of some form. Some of them are also provided with external appendages resembling spines, drum-sticks, trumpets, etc., much like the zygospores of such *Desmids* as *Euastrum*, *Micrasterias*, *Staurastrum*, etc., or again, like those appendaged eggs of certain *Copepods* often abundant on muddy seashores, and which, occurring as fossils in flints, were formerly termed *Xanthidia*. The cysts of the *Chrysomonadineae*, however, are much smaller than any of the organisms mentioned as resembling them. No doubt can arise regarding the siliceous nature of these cysts, as they

have passed through the boiling acids employed to clean the diatomite. Such remains are figured in Ehb., Mik., Taf. i, xiv, xviii, xx, xxxiv, xxxv A, xxxix; Ehb., Am., Taf. i, ii; and the living organisms are described in the readily accessible Süsswasserflora, edited by A. Pascher, Heft ii, Flagellatae, and the works there referred to.

In conclusion I wish to record my obligations to Mr. West for the assistance he has given me, as well as for his unpublished notes freely placed at my disposal.

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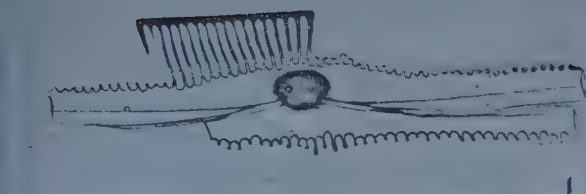
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DESCRIPTION OF FIGURES.

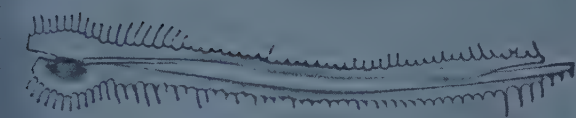
- Fig. 1. *Pinnularia nobilis*. An eroded fragment, $\times 580$, showing central area pitted and most of the lateral chambers (striae) broken away, leaving serrated margins to the central area. The chambers that remain show but faintly the "longitudinal band" because the inner side has been partially eroded.
- Fig. 2. *Pinnularia stretoraphe*, $\times 580$. Half of an axial area with the lateral chambers eroded away, leaving a toothed edge to the area which is slightly pitted and a little bent.

- Fig. 3. *Pinnularia alpina*, $\times 580$. A partially eroded specimen, but illustrating the distant striae characteristic of the small section of the genus to which it belongs.
- Fig. 4. A portion of a girdle of *Pinnularia* sp., $\times 1140$. This normally consists of a belt of translucent siliceous material, having a narrow band of minute punctae arranged in close rows transverse to the long axis. This specimen has been greatly eroded, and the narrow band of punctae, which are less eroded on the lower side of the specimen, are almost invisible. The shadowy margin at the upper edge is where the girdle bends to fit the rim of the valve.
- Fig. 5. Abnormal form, probably *Pinnularia Dactylus*, $\times 1140$. This may be a sporangial frustule, but it is certainly an interesting form.
- Fig. 6. *Pinnularia Dactylus*, $\times 580$. Eroded specimen showing the lateral chambers broken away on one side, leaving a toothed edge along which may be seen the delicate siliceous membrane.
- Fig. 7. *Cymbella lanceolata*, $\times 1140$. An eroded fragment showing the punctae on some of the striae. The shadowy margins of this specimen are out of focus owing to the natural shape of the valve and to the fragment being bent. These punctae, opposite the central nodule, are shown at the white dot or actual pore focus. The black dots indistinctly seen at other parts are a defraction effect of the same structure seen at a different focus due to curvature of the specimen.
- Fig. 8. *Stauroneis Phoenicenteron*, forma, $\times 1140$. An eroded fragment showing the stauron and part of the axial area with raphe, also remains of the striae exhibiting punctae. The pitting of the axial area and stauron is seen in this specimen. Some of the punctae are at the white dot, others at the black dot focus.
- Fig. 9. *Cymbella aspera*, $\times 1140$. An eroded portion of the valve showing the punctae which form the striae. Parts of this specimen are out of focus owing to the natural curvature of the valve, other parts being bent by its fracture. This is a much coarser species than *C. lanceolata*. A small part of the specimen below the central nodule is in actual pore focus, while the major portion above is at the focus of the black dot defraction image, more of this is shown because the defraction image has a longer range of focus than the actual pore image.

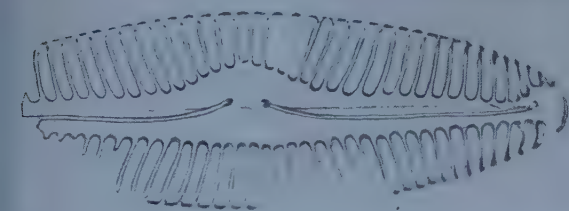
Note.—These eroded specimens, shown clearly enough under the microscope, are more difficult to photograph than the perfect examples, owing to the lower contrast which they display.



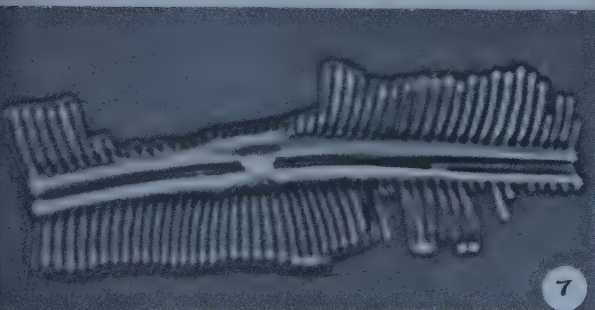
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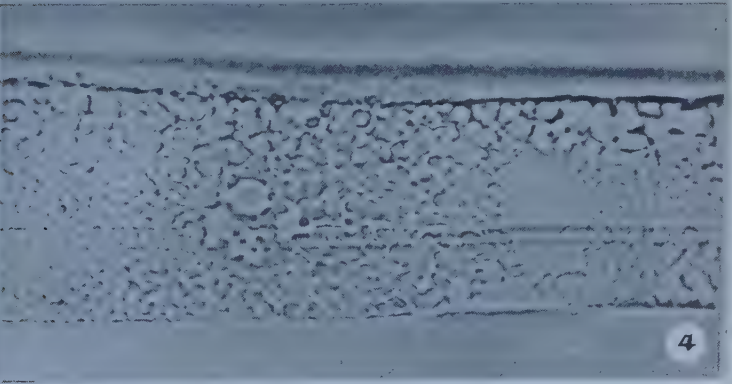
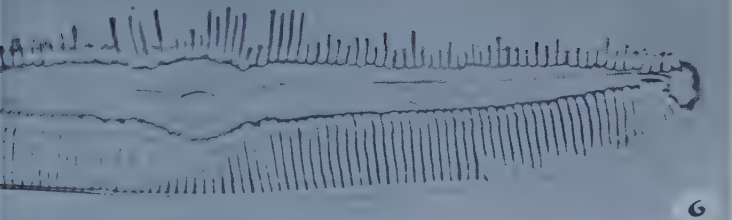
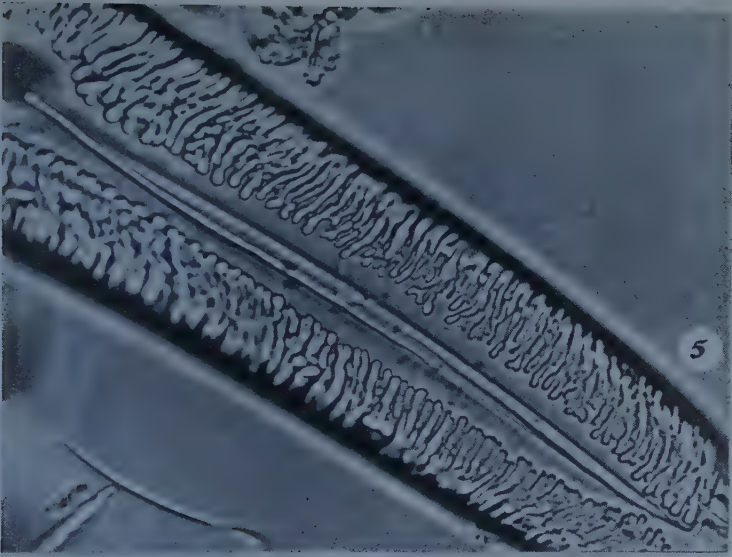


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George West, Photo.



George West, Photo.

THE ORIGIN OF ADVENTITIOUS GROWTHS IN COLEUS. By
EDITH PHILIP SMITH, B.A., F.L.S. (With Pl. X.)

(Read 21st May 1925.)

The term "Adventitious Growth" is intended to apply strictly to tissues or organs developed by the plant out of the order of its normal morphology, whether such growths occur naturally or are artificially induced, as in vegetative propagation. It is not intended to include the development of dormant buds, etc.

With this qualification new adventitious growths may be divided into three classes: callus, roots, and shoots. They may further be considered in relation to their conditions of appearing, whether naturally or artificially induced. Thus, in *Coleus*, callus may occur as healing tissue for an accidental wound in the normal plant, or at the severed end of a cutting. Adventitious roots occur freely in the normal plant when it is growing under moist conditions, and especially when the shoots are weak and bend over of their own weight. They may be induced artificially on a cutting of any part of the plant. Adventitious shoots have not been observed in nature. They can only be induced with great difficulty in propagation.

I. CALLUS.

When a portion of a *Coleus* plant is severed and put in a propagating frame, changes take place at the cut end. In one experiment thirty-two leaves were put in the frame: after two days the cells of the cut surface of the petiole were already blocked with substances staining with Sudan III.: after six days rooting had begun. The extent of the meristematic activity incited by the isolation of the part was not great: only six to eight layers of cells were involved. Pith, cambium, and cortex all took part, with indication of greatest activity in the cambium. The whole process is so rapid, however, that once a seal is established over the wounded cells, cell-division in the underlying layers must be nearly simultaneous in all the tissues involved. The figure (fig. 1) shows the extent of the meristem. The ends of the vessels

are beginning to be closed by cells produced by the cambium. When the cut ends were kept in darkness and moisture no further development of callus took place, but rooting followed directly. This applies to the callus of the stem, both at node and internode, as well as to the petiole. In an attempt to induce budding from the internode, many stem cuttings and plants in pots were severed at an internode. No new buds were produced, but the cut end became quite definitely corky, although examination showed that this was confined to at most three layers of cells on the outside.

Callus formation, then, in *Coleus* amounts to no more than the development of a meristematic zone which gives six to ten cells beneath a thinly suberised seal. The degree of suberisation depends on the degree of moisture and the amount of oxygen to which the cut end of the severed part is exposed.

II. Roots.

Rooting takes place so quickly in *Coleus* that the question of pre-existing root initials (primordia) is raised. Accordingly, a large number of stems of the varieties used for making cuttings were examined. All the pieces chosen were young vigorous shoots, as upright as possible, and showing no external signs of rooting. (It was observed that as soon as a stem begins to bend over by its own weight a few roots are developed: these are shorter and stouter than the roots produced in the propagating frame.) In these apparently normal and vigorous stems there were no signs of organised meristems which could be interpreted as root initials, either at the node or at the internode. The exact time of development of roots by a cutting is, of course, conditioned by its previous history (particularly by the temperature and humidity of the house in which it has been growing), and by the temperature, etc., of the propagating frame. In all these experiments the average time required to produce roots $\frac{1}{2}$ to 1 in. long was five days, the shortest time observed being four, and the longest time six days. It seems likely, therefore, that using a propagating frame at a temperature of 70° F., and a form of *Coleus Blumei* previously grown at the same temperature, that two days are necessary to seal the cut, and that the root primordia are organised between

the third and fourth day. (These times are, of course, only intended to apply to the conditions of experiment stated.)

The origin of the adventitious roots has been traced in the node and internode of the stem, and in the petiole and leaf-blade (midrib).

The anatomy of the primary stem of *Coleus* is simple. The stem is approximately square in section at the internode, the opposite and decussate leaves being attached to the flat sides. Internally, each of the four angles of the stem is marked by a large bundle-group (derived from the leaf-trace of the leaf above), linked by a line of cambium to four smaller alternating vascular strands. The pith is large and soft, and rigidity is principally maintained by turgor, although the stem is stiffened to a certain extent by a casing of collenchyma immediately within the epidermis.

The stem propagates with equal readiness at the node or the internode: it seems to be immaterial where the cutting is made. When a stem cutting strikes, the first roots appear in four ranks, corresponding to the four large vascular strands. This arrangement may be obscured later by roots which arise irregularly in between, but at first it is very striking.

The first recognisable sign of the development of an adventitious root is the appearance in the cambium of a nest of highly meristematic cells, having dense protoplasm and large nuclei with very prominent nucleoli. It is evident from the size of the cells and the position of their walls that cell-divisions have been taking place both radially, transversely, and tangentially. The earliest stage figured shows that a block of about ten cells in each plane is involved (fig. 1). The tangential growth-thrust of what may now be called the organised meristem soon crushes the cells in its path. It seems possible that enzyme action also takes part, because several preparations show gaps in the surrounding tissue which are suggestive of digestion by the advancing root-tip. Once started, growth is very rapid, and if the material is fixed sufficiently quickly mitotic figures may be seen in many of the nuclei.

The root soon differentiates; usually a central core (plerome (*p*), fig. 2) may be distinguished from the rest while it is about thirty cells long, and the root-cap is well marked before it has emerged from the tissues of the cutting. The vascular connection is established later, lignification

beginning in the root and extending backwards to make contact with the wood of the stem.

There is no difference between the origin of the root from the node and the internode of the stem.

In the petiole, as in the stem, the root initial arises in connection with the cambium of a vascular bundle, or sometimes where two bundles are close together, with the cambiums of both (figs. 3, 4). In fig. 4 the root happens to be coming about the middle of the horse-shoe ring of bundles in the petiole; roots have been observed coming from bundles in every other situation in the petiole, so that evidently the relative position of the bundle has no influence on rooting. The cells of the pterome and the root-cap (*r.c.*) are well seen in this section, also the suggestion of disintegration of the tissues round the root-cap (*d*).

When a *Coleus* leaf is laid flat in the frame and the midrib severed, rooting will take place from each of the cuts. Here, also, the root comes from the cambium of the vascular bundle.

The origin of roots in *Coleus* cuttings from "near the true cambium" is mentioned by Corbett (1).

III. SHOOTS.

Adventitious shoots have not been observed by the writer on any *Coleus* plant in nature. Many attempts have been made throughout two growing seasons to induce the development of adventitious buds, but so far with indifferent success.

About fifty cuttings of *Coleus* were put in the frame, the tips cut off at an internode. These cuttings rooted freely, the cut apices became sealed over with a light corky seal, but no buds developed on the cuts. The cuttings were potted on, and the lateral growths rubbed out as they developed, but they refused to respond.

In another experiment twenty-three established plants in small pots, growing on the stage in the propagating house, were cut across on the 30th June 1924. Two to five pairs of leaves were left below the cut, and the lateral buds were taken out with a sharp knife in order to minimise injury. As before, the cut end was covered with a thin layer of cork. The secondary axillary buds, which are normally present, developed first. If these growths were also removed, no further

budding took place. The petioles of the remaining leaves grew to five or six times their normal length, and the leaves themselves grew larger and lost their clean-cut outline. In a few weeks they became quite stiff with starch deposits. The colour deteriorated markedly. Some of the plants died off, but most of them survived till the end of October. On the 29th of October the survivors were again cut over, and, together with six new plants, had a quantity of glass wool wrapped round their apices. The wool was kept moist in the hope that a moist and slightly alkaline environment would favour the development of shoots. In this state they remained through the winter. No progress having been made, in April 1925 the surface was cut afresh, and the plants watered with a 0.2 per cent. solution of potassium nitrate. They responded quickly to the increased nitrogen supply, and new buds appeared *axillary to the leaf-scars*. The colour of the leaves also rapidly improved. In no case did any indication appear of buds developed on the cut internode, as happens in *Acanthus* (2). Evidently the residual axillary meristem is the only part of the stem which remains sufficiently plastic to give rise to shoot-buds under the stimulus of propagation. The importance of the carbon-nitrogen balance in regeneration is also indicated by the experiments with increased nitrate supply.

In leaf-cuttings which had been separated some distance up the petiole to avoid the possibility of pulling off the secondary axillary bud referred to, no budding at all was induced, although more than one hundred leaves, including eight distinct forms of *Coleus*, were tested.

Until more is known of the factors governing the production of roots or shoots—whether the occurrence of one or the other is conditioned by different kinds or concentrations of plastic material, or by the acidity or alkalinity of the medium, or by specific hormones, or by a combination of all these factors and others—we cannot attempt an explanation of why it should be so difficult to induce bud-formation in *Coleus*, and be content with a simple statement of facts of observation.

Since the above was written Mr. L. B. Stewart has succeeded in producing new buds, both upon the old woody stem

and upon the roots of *Coleus*. The plants were potted with the roots partially above the earth, and the stem cut back to a stump: the whole was kept in a propagating case. Proliferation occurred freely at the base of the stem on the site of the old leaf-scars, and buds also appeared on the roots. These shoots were pricked off as soon as they could be handled, and then potted on. All the new shoots were pure green, regardless of the original colour of the plant.

The anatomy of these growths will be reported on later.

REFERENCES.

- (1) CORBETT, L. C.: The Development of Roots from Cuttings. *Meehan's Monthly*, vii (1897), p. 32.
- (2) STEWART, L. B.: On *Acanthus montanus*. *Trans. Bot. Soc. Edin.*, xxviii (1922), p. 117.

DESCRIPTION OF PLATE.

Fig. 1. Longitudinal section of the stem of *Coleus*, to show basal callus and a root initial. Fixed Blés' fluid. Paraffin section, 12 μ thick; stained safranin and hæmatoxylin. Negative on Eastman commercial ortho. film, Wratten "G" filter. $\times 50$.

The cutting from which this section was taken was made just below a node. The xylem is somewhat shattered, but details of spiral and pitted vessels can be made out. Meristematic activity is seen in all the tissues, except the epidermis. The surface cells of the callus are lightly suberised. The root initial is seen.

Fig. 2. Transverse section of the stem of *Coleus*, showing an adventitious root. Fixed Blés' fluid. Paraffin section, 12 μ thick; stained gentian violet, light green. Negative on Eastman commercial ortho. film, Wratten "BG" filters. $\times 70$.

Shows connection with the cambium of the stem, rapid differentiation in the root, and the great increase in the density of the cytoplasm towards the root-apex.

Figs. 3, 4. Transverse sections of the petioles of *Coleus*, showing adventitious roots in connection with the cambium of the vascular bundles. Fixed, stained, and photographed as in fig. 2. $\times 70$.

There is a suggestion of digestion of the tissues (at *d*) of the petiole round the root-cap.

p, plerome; *r.c.*, root-cap.

d. r. c.



ADDITIONS TO THE FLORA OF ORKNEY, AS RECORDED IN
WATSON'S "TOPOGRAPHICAL BOTANY," Second Edition
(1883). By Colonel H. H. JOHNSTON, C.B., C.B.E.,
D.Sc., M.D., C.M., F.R.S.E., F.L.S.

(Read 19th June 1925.)

This paper forms a continuation of seven papers on the same subject, one of which I read before the Scottish Natural History Society on 4th April 1895, and which was published in "The Annals of Scottish Natural History," No. 15, pp. 173-181 (July 1895), and the other six before the Botanical Society of Edinburgh on 15th January 1914, 10th June 1920, 17th March 1921, 20th April 1922, 19th April 1923, and 19th June 1924, and which were published in the Society's "Transactions," vol. xxvi, pp. 207-217 (1914); vol. xxviii, pp. 23-42 (1920), pp. 51-66 (1921), pp. 98-117 (1922), and pp. 174-183 (1923); and vol. xxix, pp. 83-95 (1924), respectively.

Before and after the publication of the second edition of Watson's "Topographical Botany," in 1883, several of the plants mentioned in the following list have been recorded from Orkney by me and other botanists; but as the value of botanical records is greatly enhanced by the possession of authentic specimens, I have included in this list the names of all specimens in my herbarium, which are either additional to or confirm doubtful records of the plants recorded from county No. 111 Orkney in the second edition of the above-mentioned book.

In the case of those plants which have already been recorded from Orkney, references are given in the following list, under each species and variety, to the books in which the records have been published. These records are principally contained in "A Tour through some of the Islands of Orkney and Shetland," in the year 1804, by Patrick Neill (1806); "Notice of some of the rarer Plants observed in Orkney during the Summer of 1849," by John T. Syme, Esq., published in the "Transactions of the Botanical Society of Edinburgh," vol. iv, pp. 47-50 (1850); "Florula Orcadensis—A list of plants reported to occur in the Orkney Isles," by H. C. Watson, Esq., F.L.S., published in "The Journal of Botany," No. xiii,

pp. 11-20 (January 1864); Annual Reports of the Botanical Exchange Club of the British Isles; "A new List of the Flowering Plants and Ferns of Orkney," edited by W. A. Irvine Fortescue, and published in "The Scottish Naturalist" (1882-1884); "Supplement to Topographical Botany," ed. ii, by Arthur Bennett, A.L.S. (1905); and "Flora Orcadensis," by Magnus Spence, F.E.I.S. (1914).

The nomenclature followed is that of the second edition of Watson's "Topographical Botany" (1883), except in the case of species and varieties which are not recorded in that work. In the latter case the nomenclature adopted is that of "The London Catalogue of British Plants," tenth edition (1908), except where otherwise stated. Non-native plants, which have become naturalised in Orkney, are distinguished by a * prefixed to the names, and the names of casuals are printed in italics.

Of the 39 species, varieties, forms, and hybrids recorded from Orkney in the following list, 26 are native, 8 are mere casuals introduced into Orkney through the agency of cultivation, and 5 were planted by man.

ABBREVIATIONS.

"Annals Scot. Nat. Hist."=The Annals of Scottish Natural History.
Bennett, "Suppl. Top. Bot."=Supplement to H. C. Watson's Topographical Botany, second edition. By Arthur Bennett, A.L.S. (1905).

"Bot. Exch. Club Report" (separate Reports by the Secretary and Distributor)=Report of The Botanical Exchange Club of the British Isles, at present called The Botanical Society and Exchange Club of the British Isles.

"Journ. Bot."=The Journal of Botany.

"Lond. Cat."=The London Catalogue of British Plants.

Neill, "Tour"=A Tour through some of the Islands of Orkney and Shetland, in the year 1804. By Patrick Neill, A.M., Secretary to the Natural History Society of Edinburgh (1806).

"Scot. Nat."=The Scottish Naturalist.

Spence, "Flora Orcadensis"=Flora Orcadensis. By Magnus Spence, F.E.I.S. (1914).

Watson, "Top. Bot."=Topographical Botany, second edition. By H. C. Watson (1883).

CORRECTIONS.

In "Trans. Bot. Soc. Edin.," vol. xxvi, p. 213 (1914), lines 1 and 2 at top of page, for "CAMBRICA (*Huds.*) (*fide* Arthur Bennett)," read *PLUKENETIANA*, *Druce* (*fide* G. C. Druce, 16th December 1922).

The following corrections in the names of some of my Orkney specimens of *EUPHRASIA* are made on account of my having accepted the determinations of Mr. Dennis Lumb in preference to those of the late Mr. Cedric Bucknall and the late Reverend Edward Shearburn Marshall :—

In "Trans. Bot. Soc. Edin.," vol. xxvi, p. 214 (1914), in lines 5 and 6 from top of page, for "*E. CURTA*, *Wettst.*, var. *GLABRESCENS*, *Wettst.* (*fide* E. S. Marshall)" read *E. BREVIPILA*, *Burnat et Gremli* (*fide* Dennis Lumb).

In "Trans. Bot. Soc. Edin.," vol. xxvi, p. 214 (1914), in line 2 from bottom of page, for "*EUPHRASIA CURTA*, *Wettst.* (*fide* E. S. Marshall)," read *EUPHRASIA BOREALIS*, *Townsend* (*fide* Dennis Lumb).

In "Trans. Bot. Soc. Edin.," vol. xxvi, p. 215 (1914), lines 6–17 from top of page, delete from "*EUPHRASIA CURTA*, *Wettst.*, var. *GLABRESCENS*, *Wettst.*," to the end of the paragraph "August 1901, p. 270"; and redistribute the stations among the following species, viz. :—*EUPHRASIA BREVIPILA*, *Burnat et Gremli* (*fide* Dennis Lumb).—Grassy banks at burnside, 270 feet above sea-level, Burn of Selta, Stromness, Mainland, 23rd August 1912, H. H. Johnston, native; and heathery and grassy pasture at top of cliffs-at the seashore, 130 feet above sea-level, Brims, Waas, Hoy, 4th August 1912, H. H. Johnston, native.

EUPHRASIA SCOTTICA, *Wettst.* (*fide* Dennis Lumb).—Marsh, 300 feet above sea-level, Dale of Oback, Orphir, Mainland, 9th July 1913, H. H. Johnston, native.

EUPHRASIA CÆRULEA, *Tausch.* (*fide* Cedric Bucknall and Dennis Lumb).—Damp pasture on hillside, 300 feet above sea-level, Wart Hill, Hoy, 15th August 1912, H. H. Johnston, native. See "Bot. Exch. Club Distributor's Report for 1920," vol. vi, part ii, p. 257 (September 1921); and "Trans. Bot. Soc. Edin.," vol. xxviii, part ii, pp. 53 and 58 (1921).

In "Trans. Bot. Soc. Edin.," vol. xxviii, part i, p. 34, lines 19–22 from top of page (1920), delete from "This species" to the end of the paragraph "my herbarium."

CLASS I.—DICOTYLEDONS.

Cochlearia Armoracia, Linn. [= *Armoracia rusticana*, G. M. et S.].—Reference No. 2872 A, vacant poultry yard, 10 feet

above sea-level, Masons Arms Hotel, Stromness Town, Stromness, Mainland, 24th October 1924, Henry Halcro Johnston. Not native. Rare. Plants sparingly in flower. See the Reverend Dr. George Barry's "The History of the Orkney Islands," ed. i, p. 275 (1805); Dr. A. R. Duguid's manuscript "Flora Orcadensis" (1858); "Journ. Bot.," No. xiii, p. 13 (January 1864); and "Scot. Nat.," vol. xlvii, p. 322 (July 1882).

Viola tricolor, Linn., subspecies *genuina*, Wittrock, var. *færøensis* (W. Becker), C. H. Ostenfeld, in "Botany of the Færøes," part iii, p. 856 (1908) (*fide* J. Clausen and C. H. Ostenfeld, 25th May 1925).—Reference No. 2378, hay-field, 20 feet above sea-level, Quoy, Fara, North Isles, 5th July 1923, H. H. Johnston. Not native. A weed of cultivation. Common. Plants in full flower. Two upper petals uniformly violet; two lateral petals purplish-blue, each with three dark violet lines; lower petal purplish-blue, with 7 dark violet lines, and a yellow base; spur of lower petal dark purple, longer than the calycine appendages. Professor C. H. Ostenfeld, in a letter to me, dated, at Copenhagen, 25th May 1925, mentions that my Orkney specimens have the same "stiff 'ciliation' on the leaf blades and ribs, and the leaf blades more rounded than usual," as occur in the same variety in Iceland and the Færøes. A new record for this variety for H. C. Watson's county No. 111 Orkney, discovered by me on 5th July 1923, but it is most probable that many specimens of *Viola tricolor*, Linn., collected by me in Orkney between 1874 and 1921, and recorded as "*Viola Lloydii*, Jordan," "*Viola variata*, Jordan," and "*Viola lepida*, Jordan" (*fide* W. G. Travis), in "Trans. Bot. Soc. Edin.," vol. xxviii, part iii, pp. 101–102 (1922), really belong to the var. *færøensis* (W. Becker) C. H. Ostenfeld. With reference to my specimens of Reference No. 2111, from Bigging, Birsay, Mainland, sent to the Botanical Exchange Club in 1922, and labelled "*Viola tricolor*, Linn., var. *Lloydii* (Jordan) (*fide* W. G. Travis)," Dr. Eric Drabble wrote as follows in "Bot. Exch. Club Report for 1922," vol. vi, part vi, p. 828 (May 1923): "This is not the least like *Lloydii*. I am not yet prepared to identify these Orkney plants with any continental pansies."

CERASTIUM TETRANDRUM, Curtis, var. EGLANDULOSUM, C. E. Salmon, in "The Journal of Botany," vol. lxi, pp. 89–90

(March 1923) (*fide* C. E. Salmon, who has seen all my specimens from the following stations in ten different islands).—Reference No. 1073, short, natural, shell-sandy pasture near the seashore, 10 feet above sea-level, Newark Bay, Deerness, Mainland, 10th May 1921, H. H. Johnston, native, common, plants sparingly in flower (*Note*.—Plants of Reference No. 1227, in fruit and sparingly in flower, collected by me at the *same* station on 21st June 1921, are clothed with gland-tipped hairs, and they were named *CERASTIUM TETRANDRUM*, *Curtis*, by Mr. C. E. Salmon); Reference No. 1082, turf top of a stone wall at seashore, 10 feet above sea-level, Braebuster, Deerness, Mainland, 11th May 1921, H. H. Johnston, native, common, plants in flower (*Note*.—Plants of Reference No. 393, in dehiscent fruit, collected by me from the *same* wall-top on 21st August 1916, are clothed with gland-tipped hairs, and they were named *CERASTIUM TETRANDRUM*, *Curtis*, by Mr. C. E. Salmon); Reference No. 1095, turf top of a stone wall, 15 feet above sea-level, field south of Established Church Manse, Holm, Mainland, 12th May 1921, H. H. Johnston, native, rare, plants in full flower; Reference No. 1104, natural, shell-sandy pasture at seashore, 10 feet above sea-level, How, Backaskail Bay, Cross, Sanday, 16th May 1921, H. H. Johnston, native, common, plants in full flower; Reference No. 1591, turf top of a stone wall at roadside, 100 feet above sea-level, Flaws, Evie, Mainland, 19th May 1922, H. H. Johnston, native, common, plants in full flower (*Note*.—Plants of Reference No. 1894, in fruit and sparingly in flower, collected by me from the *same* wall-top on 26th July 1922, are clothed with gland-tipped hairs, and they were named *CERASTIUM TETRANDRUM*, *Curtis*, by Mr. C. E. Salmon); Reference No. 1667, grassy banks at seashore, 10 feet above sea-level, The Taing, Viera (also called Wire), 3rd June 1922, H. H. Johnston, native, rare, plants in flower; Reference Nos. 1696 and 1698, rocky and grassy banks near the seashore, 10 feet above sea-level, south end of Holm of Scockness, 7th June 1922, H. H. Johnston, native, common, plants in full flower; Reference No. 1768, bare soil from which the turf has been pared off, 10 feet above sea-level, Little Linga, 21st June 1922, H. H. Johnston, native, common, plants in full flower and sparingly in fruit; Reference No. 1773, grassy banks at seashore, 10 feet above sea-level, south end of Holm

of Huip, 21st June 1922, H. H. Johnston, native, common, plants in full flower and sparingly in fruit ; Reference No. 2237, grassy and rocky cliffs at seashore, 10 feet above sea-level, south side of Calf of Flotta, 1st June 1923, H. H. Johnston, native, common, plants sparingly in flower ; Reference No. 2334, short, natural pasture at seashore, 10 feet above sea-level, Middle Holm of Spurness, 29th June 1923, H. H. Johnston, native, common, plants in flower and sparingly in fruit ; Reference No. 2397, grassy banks at seashore, 10 feet above sea-level, south-west side of Calf of Eday, 6th July 1923, H. H. Johnston, native, very rare, plants in fruit ; and Reference No. 2664, short, natural, grassy pasture at top of rocky banks at seashore, 18 feet above sea-level, south-east end of Outer Holm of Stromness, 28th July 1924, H. H. Johnston, rare, one plant with dehiscent fruit. See "Bot. Exch. Club Secretary's Report for 1923," vol. vii, part i, p. 31 (November 1924).

Note.—In my herbarium I have specimens of *CERASTIUM TETRANDRUM*, *Curtis* (*fide* C. E. Salmon, who has seen all of them), clothed with gland-tipped hairs, from twenty-three different islands in Orkney. These specimens were collected between 14th May and 5th September, and, with the exception of three gatherings in May when the plants were in flower only, all the remainder of my specimens were collected after 12th June, when the plants were both in flower and fruit at the same time, or in fruit only. In the case of the *var. EGLANDULOSUM*, *C. E. Salmon*, my specimens were collected between 10th May and 28th July, but most of them were collected before 8th June, when the plants were in flower only, and the few specimens collected after 8th June were mostly more in flower than in fruit. It is remarkable that in three instances, in which I collected specimens at the *same identical stations* at different seasons of the year, *all* my specimens collected early in the year were eglandular, whereas *all* those collected later in the year were glandular. Whether, possibly, eglandular plants may become glandular later in the same year, as they become more mature, can only be ascertained by marking plants *in situ* and examining them from time to time throughout the flowering and fruiting seasons of the year.

[*Acer Pseudo-platanus*, Linn. (*fide* W. J. Bean).—Reference No. 279, grassy banks at burnside, 190 feet above sea-level, Burn of Oback, Orphir, Mainland, 13th September 1924,

X In "Trans. Bot. Soc. Edin.," vol. xxvi, p. 214 (1914), in lines 5 and 6 from top of page, for "E. CURTA, *Wettst.*, var. GLABRESCENS, *Wettst.* (*fide* E. S. Marshall)" read E. BREVIPILA, *Burnat et Gremli* (*fide* Dennis Lumb).

The following corrections in the names of some of my Orkney specimens of EUPHRASIA are made on account of my having accepted the determinations of Mr. Dennis Lumb in preference to those of the late Mr. Cedric Bucknall and the late Reverend Edward Shearburn Marshall:—

X

In "Trans. Bot. Soc. Edin.," vol. xxvi, p. 214 (1914), in line 2 from bottom of page, for "EUPHRASIA CURTA, *Wettst.* (*fide* E. S. Marshall)" read EUPHRASIA BOREALIS, *Townsend* (*fide* Dennis Lumb).

In "Trans. Bot. Soc. Edin.," vol. xxvi, p. 215 (1914), lines 6-17 from top of page, delete from "EUPHRASIA CURTA, *Wettst.*, var. GLABRESCENS, *Wettst.*," to the end of the paragraph "August 1901, p. 270;" and redistribute the stations among the following species:—

EUPHRASIA BREVIPILA, *Burnat et Gremli* (*fide* Dennis Lumb).—Grassy banks at burnside, 270 feet above sea-level, Burn of Selta, Stromness, Mainland, 23rd August 1912, H. H. Johnston, native; and heathery and grassy pasture at top of cliffs at the seashore, 130 feet above sea-level, Brims, Waas, Hoy, 4th August 1912, H. H. Johnston, native.

EUPHRASIA SCOTTICA, *Wettst.* (*fide* Dennis Lumb).—Marsh, 300 feet above sea-level, Dale of Oback, Orphir, Mainland, 9th July 1913, H. H. Johnston, native.

EUPHRASIA CÆRULEA, Tausch. (*fide* Cedric Bucknall and Dennis Lumb).—Damp pasture on hillside, 300 feet above sea-level, Wart Hill, Hoy, 15th August 1912, H. H. Johnston, native. See "Bot. Exch. Club Distributor's Report for 1920," vol. vi., part ii, p. 257 (September 1921); and "Trans. Bot. Soc. Edin.," vol. xxviii, part ii, pp. 53 and 58 (1921).

In "Trans. Bot. Soc. Edin." vol. xxviii., part i., p. 34, lines 19-22 from top of page (1920), delete from "This species" to the end of the paragraph "my herbarium."

H. H. Johnston. Not native. Four shrubs, 3-9 feet high, not in flower or fruit, were planted in the spring of 1921 by Mr. Thomas Sclater, residing at Oback, Orphir.]

ROSA OMISSA, *Déséglise*, var. *e. SUBERECTA*, *Wolley-Dod*, form β . *GLABRATA*, *Wolley-Dod* (*fide* A. H. Wolley-Dod, 23rd November 1924).—Reference No. 230, heathery banks at burnside, 90 feet above sea-level, South Burn, about 300 yards below the junction of the two burns flowing from Nowt Bield and Trowie Glen to form the South Burn, Hoy, 24th June 1914, H. H. Johnston. Native. Rare. Plants beginning to flower, and growing among *ROSA MOLLIS*, *Sm.* (*fide* William Barclay, 5th December 1914). A new record for this variety and form for H. C. Watson's county No. 111 Orkney, discovered by me on 24th June 1914. The late Mr. William Barclay was not able to identify my specimen.

[*Ribes sanguineum*, Pursh, "Flora Americae Septentrionalis," vol. i, p. 164 (1814) (*fide* W. J. Bean).—Reference No. 2797, grassy banks at burnside, 190 feet above sea-level, Burn of Oback, Orphir, Mainland, 13th September 1924, H. H. Johnston. Not native. Two shrubs, 5 feet high, not in flower or fruit, were planted in the spring of 1921 by Mr. Thomas Sclater, residing at Oback, Orphir.]

Helianthus annuus, Linn. (*fide* C. E. Hubbard).—Reference No. 2831, vacant poultry yard, 10 feet above sea-level, Masons Arms Hotel, Stromness Town, Stromness, Mainland, 24th September 1924, H. H. Johnston. Not native. One plant, in flower, only seen by me. Corolla dark yellow.

Sonchis asper, Hill, var. *c. pungens*, Bisch. (*fide* G. C. Druce, 16th December 1922).—Reference No. 1816, rubbish heap at seashore, 10 feet above sea-level, Hamla Voe in Stromness Harbour, Stromness, Mainland, 7th July 1922, H. H. Johnston. Not native. Rare. Plants in flower and sparingly in fruit. Confirms Dr. G. Claridge Druce's record of this variety from Orkney ("Kirkwall," 1920) in "Bot. Exch. Club Secretary's Report for 1920," vol. vi, part i, p. 133 (September 1921).

Crepis capillaris, Wallr. emend. Rendle et Britten, var. *a. diffusa* (DC.) (*fide* G. C. Druce, 17th December 1922).—Reference No. 533, artificial grass field, 10 feet above sea-level, Garson, Stromness, Mainland, 5th September 1919, H. H. Johnston. Not native. A weed of cultivation. Common. Plants in full flower.

Crepis capillaris, Wallr. emend. Rendle et Britten, var. *anglica*, Druce et Thellung, in "Bot. Exch. Club Secretary's Report for 1923," vol. vii, part i, pp. 42-43 (November 1924) (*fide* G. C. Druce).—Reference No. 860, gravelly ground round filter beds, 200 feet above sea-level, Kirkwall Waterworks Reservoir, near Hatston, Saint Ola, Mainland, 9th August 1920, H. H. Johnston. Not native. Common. Plants in full flower and sparingly in fruit. Leaves glabrous, except a few scattered hairs on the midrib and veins. See "Bot. Exch. Club Secretary's Report for 1920," vol. vi, part i, p. 132 (September 1921), where this variety is erroneously recorded as "*C. NICAENSIS* Balb.,"; *ibid.* "Report for 1921," vol. vi, part iii, p. 386 (September 1922), where, under "*C. NICAENSIS* Balb.," it is noted as "a. var. of *C. capillaris*,"; *ibid.* "Report for 1922," vol. vi, part v, pp. 611-612 (May 1923), where it is recorded as "*CREPIS CAPILLARIS* (L.) Wallr., nov. var. *GLANDULOSA*, Druce," but, as this name was published without a Latin diagnosis, and as there are other forms of *Crepis capillaris*, Wallr. emend. Rendle et Britten, which are also glandular, it was withdrawn in *ibid.* "Report for 1923," vol. vii, part i, pp. 42-43 (November 1924), and the name "var. *ANGLICA*, Druce and Thellung," with a Latin diagnosis, was substituted for it.

SOLIDAGO VIRGA-AUREA, Linn., var. *PLUKENETIANA*, Druce, in "Bot. Exch. Club Secretary's Report for 1921," vol. vi, part iii, p. 290 (September 1922) (*fide* G. C. Druce, 16th-18th December 1922).—Heath, 25 feet above sea-level, Veness, Orphir, Mainland, 19th July 1912, H. H. Johnston, native, common, plants in flower; heathery hill-top, 650 feet above sea-level, hill on south-west side of Hoglinns Water, Waas, Hoy, 13th August 1913, H. H. Johnston, native, small plants sparingly in flower; Reference No. 811, stony summit of hill, 1560 feet above sea-level, Wart Hill, Hoy, 31st July 1920, H. H. Johnston, rare, one small plant in flower; and Reference No. 1849, clefts of rocky sea-cliffs, 15 feet above sea-level, Point of Tuberry, Cava, 10th July 1922, H. H. Johnston, native, rare, plants sparingly in flower. See "Bot. Exch. Club Secretary's Report for 1922," vol. vi, part v, p. 729 (May 1923).

SOLIDAGO VIRGA-AUREA, Linn., var. *PLUKENETIANA*, Druce, sub.-var. *ACUTIFOLIA*, Druce, in "Bot. Exch. Club Secretary's

Report for 1921," vol. vi, part iii, page 290 (September 1922) (*vide* G. C. Druce, 17th December 1922).—Reference No. 843, stony and heathery hillside, 380 feet above sea-level, Burandie, Hoy, 5th August 1920, H. H. Johnston, native, rare, plants in full flower; and Reference Nos. 894 and 1019, heathery hillside, 280 feet above sea-level, Mui Fea (erroneously called "Erne Toog" in 1-inch Ordnance Map published in 1912), Stromness, Mainland, 17th August 1920 (plants in full flower), and 20th September 1920 (plants sparingly in flower and fruit), H. H. Johnston, native, rare. See "Bot. Exch. Club Secretary's Report for 1922," vol. vi, part v, p. 729 (May 1923).

JASIONE MONTANA, Linn., var. *LATIFOLIA*, H. W. Pugsley.—Grassy banks at seashore, Carrick, Eday (*vide* G. C. Druce), 11th July 1883, H. H. Johnston, native, plants sparingly in flower: turf wall on hillside and grassy banks at seashore, west side of Eday, 11th July 1883, H. H. Johnston, native, plants sparingly in flower; and Reference No. 2408 (*vide* C. E. Salmon, 27th March 1924), grassy and rocky banks at seashore, 10 feet above sea-level, south-west side of Calf of Eday, 6th July 1923, native, rare, plants sparingly in flower, corolla and style purplish-blue. See "Bot. Exch. Club Secretary's Report for 1922," vol. vi, part v, p. 736 (May 1923).

[*Fraxinus excelsior*, Linn.—Reference No. 2795, grassy banks at burnside, 190 feet above sea-level, Burn of Oback, Orphir, Mainland, 13th September 1924, H. H. Johnston. Not native. Three shrubs, 2 feet, 7 feet, and 9 feet high, not in flower or fruit, were taken by Mr. Thomas Sclater, residing at Oback, Orphir, from Skaill, Orphir, and planted by him at the Burn of Oback, in the spring of 1921.]

Galeopsis versicolor, Curt. [= *Galeopsis speciosa*, Mill.] (*vide* Arthur Bennett, 15th October 1924).—Reference No. 2830, vacant poultry yard, 10 feet above sea-level, Masons Arms Hotel, Stromness Town, Stromness, Mainland, 24th September 1924, H. H. Johnston. Not native. Three plants, in full flower, only seen by me. Confirms the late Robert Heddle's record of this casual alien from Orkney ("Cornfields, Orphir. Westness" in Rousay) in Dr. A. R. Duguid's manuscript "Flora Orcadensis" (1858). See "Scot. Nat.," No. 30, p. 99 (April 1899); Bennett, "Suppl. Top. Bot.," p. 64 (1905); and Spence, "Flora Orcadensis," p. 55 (1914).

PLANTAGO MARITIMA, Linn., var. *DENTATA*, Wirtg. (*fide* G. C. Druce, 1921).—Hoy, 5th July 1877, H. H. Johnston. Native. A new record for this variety for H. C. Watson's county No. 111 Orkney, discovered by me on 5th July 1877.

PLANTAGO MARITIMA, Linn., var. *LEPTOPHYLLA*, Mert. et Koch (*fide* G. C. Druce, 1921).—Cliffs at seashore, Veness, Orphir, Mainland, 14th August 1876, H. H. Johnston. Native. A new record for this variety for H. C. Watson's county No. 111 Orkney, discovered by me on 14th August 1876.

PLANTAGO MARITIMA, Linn., var. *LANOSA* (Edmondston, "Flora of Shetland," p. 17 (1845), as *PLANTAGO SETACEA*, Edmondston, var. β . *LANOSA*, Edmondston) (*fide* G. C. Druce, January 1923).—Reference No. 1186, short, natural pasture near edge of sea-cliffs, 30 feet above sea-level, Quendale, Rousay, 15th June 1921, H. H. Johnston. Native. Common. Plants in full flower. Leaves linear, entire, glabrous, flat above, convex beneath, fleshy, woolly at the base. Confirms Dr. G. Claridge Druce's record of this variety from Orkney ("near Black Craig," Stromness, Mainland, 7th August 1920) in "Bot. Exch. Club Secretary's Report for 1920," vol. vi, part i, p. 42 (September 1921).

PLANTAGO EDMONDSTONII, Druce, in "Bot. Exch. Club Secretary's Report for 1920," vol. vi, part i, p. 41 (September 1921) (*fide* G. C. Druce, 1921).—Edge of cliffs at seashore, Hellia, south-west of the Kame, Hoy, 20th June 1883, and 9th August 1886 (in company with the late Reverend William R. Linton), H. H. Johnston. Native. See under *PLANTAGO MARITIMA*, Linn., var. *HIRSUTA*, Syme, in "Bot. Exch. Club Report for 1886," p. 157 (1887); "Annals Scot. Nat. Hist.," No. 15, p. 179 (July 1895), and a corrected Reprint of pages 173–181 thereof (1925); Spence, "Flora Orcadensis," p. 60 (1914); and "Bot. Exch. Club Secretary's Report for 1921," vol. vi, part iii, pp. 515–517 (1922).

Chenopodium album, Linn., var. *b. virescens*, Wahlenberg, of "The Cambridge British Flora," by C. E. Moss, vol. ii, p. 158 (1914) [= *Chenopodium album*, Linn., var. *c. paganum* (Reichenbach) of "The London Catalogue of British Plants," ed. vii (1874)] (*fide* A. J. Wilmott, 23rd January 1925).—Reference Nos. 2828 and 2867, vacant poultry yard, 10 feet above sea-level, Masons Arms Hotel, Stromness Town, Stromness, Mainland, 24th September 1924 (plants in full

flower), and 24th October 1924 (plants in withered flower), H. H. Johnston. Not native. Rare.

POLYGONUM ÆQUALE, *Lindman* (which includes POLYGONUM ARENASTRUM, *Boreau*) (*fide* A. J. Wilmott, 4th December 1924).—Reference No. 2825, grassy and stony ground, site of former heaps of seaweed, at seashore, near cultivated land, 10 feet above sea-level, Clett, between the Nevi and Fishy Geo, Graemsay, 24th September 1924, H. H. Johnston. Native. Common. Plants in full flower. Perianth-segments green, with *white* margins and apex. A new record for this species for H. C. Watson's county No. 111 Orkney, discovered by me on 24th September 1924. This species grew among plants of Reference No. 2824, POLYGONUM AVICULARE, *Linn.*, *var. b. VULGATUM*, *Syme* (*fide* Arthur Bennett, 17th October 1924), in full flower, with *crimson-pink* margins and apex on the green perianth-segments, but, with reference to my specimens of these latter plants, Mr. A. J. Wilmott, in a note dated 4th December 1924, wrote as follows:—"There are no ripe fruits, and these are essential for critical determination in this group. I think it only a well-grown form of Reference No. 2825 (although it might conceivably be a young Raii, I think this unlikely)."

[*Populus candicans*, Ait. (*fide* W. J. Bean).—Reference No. 2796, grassy banks at burnside, 190 feet above sea-level, Burn of Oback, Orphir, Mainland, 13th September 1924, H. H. Johnston. Not native. One shrub, 3 feet high, not in flower or fruit, was taken from Skaill, Orphir, by Mr. Thomas Selater, residing at Oback, Orphir, and planted by him at the Burn of Oback in the spring of 1921.]

CLASS II.—MONOCOTYLEDONS.

ORCHIS INCARNATA, *Linn.*, *var. PULCHELLA*, *Druce*, in "Bot. Exch. Club Secretary's Report for 1917," vol. v, part i, pp. 167-168 (September 1918) (*fide* G. C. Druce, 4th August 1920).—Marsh, 60 feet above sea-level, Kirbister, Orphir, Mainland, 2nd July 1912, H. H. Johnston, native, rare, plants in full flower; and marsh, 80 feet above sea-level, South Burn, Hoy, 24th June 1914, H. H. Johnston, native, rare, plants in full flower. A new record for this variety for H. C. Watson's county No. 111 Orkney, first discovered by me on 2nd July 1912.

ORCHIS INCARNATA, *Linn.*, var. DUNENSIS, *Druce*, in "Bot. Exch. Club Secretary's Report for 1915," vol. iv, part iii, p. 212 (April 1916) (*vide* G. C. Druce).—Reference Nos. 1146 and 1519, marshy lochside, 28 feet above sea-level, Loch of Skaill, Sandwick, Mainland, 1st June 1921 (plants in full flower), and 4th October 1921 (plants in fruit), H. H. Johnston, Native. Common. See "Bot. Exch. Club Secretary's Report for 1921," vol. vi, part iii, p. 398 (September 1922).

Up to the year 1917, the name "*ORCHIS LATIFOLIA*, *Linn.*," was used in all books on the flora of Orkney for those Marsh Orchids which are now included under *ORCHIS PRAETERMISSA*, *Druce*, and its variety *PULCHELLA*, *Druce*, and *ORCHIS PURPURELLA*, *T. et T. A. Stephenson*, and to hybrids of these two species and variety, and also to the darker purple-flowered hybrids between them and *ORCHIS MACULATA*, *Linn.*, *subspecies* *ERICETORUM*, *Linton* [= *ORCHIS MACULATA*, *Linn.*, in the opinion of Dr. G. Claridge Druce]. All my specimens of the following orchids have been identified by the Reverend Dr. T. Stephenson, and, with a few exceptions, the plants collected by me in 1923 and 1924 were sent to him in the fresh living state, and then returned to me for preservation after they had been identified by him.

ORCHIS PRAETERMISSA, *Druce*, in "Bot. Exch. Club Secretary's Report for 1913," vol. iii, part v, pp. 340-341 (February 1914) (*vide* T. Stephenson, 26th June 1924).—Reference No. 2511, marsh, 200 feet above sea-level, Mousland, near the Burn of Selta on its north side, Stromness, Mainland, 23rd June 1924, H. H. Johnston. Native. Common. Plants in full flower. Confirms the record of this species from Orkney ("Sanday (St. Quintin)") in Bot. Exch. Club Secretary's Report for 1917," vol. v, part i, p. 161 (September 1918).

ORCHIS PRAETERMISSA, *Druce* × *ORCHIS PURPURELLA*, *T. et T. A. Stephenson* (*vide* T. Stephenson, 26th June 1924).—Reference No. 2512, marsh, 200 feet above sea-level, Mousland, near the Burn of Selta on its north side, Stromness, Mainland, 23rd June 1924, H. H. Johnston. Native. Rare. Plants in full flower. A new record for this hybrid for H. C. Watson's county No. 111 Orkney, discovered by me on 23rd June 1924.

ORCHIS PRAETERMISSA, *Druce*, var. *PULCHELLA*, *Druce*, in "Gardeners' Chronicle," series iii, vol. lxxvii, pp. 76-77 (1920)

(*fide* T. Stephenson, 24th June 1924, 15th July 1924, and 12th March 1925).—Meadow, Scapa, Saint Ola, Mainland, 25th July 1876, H. H. Johnston, plants in flower ; pasture, Swanbister, Orphir, Mainland, 18th June 1877, H. H. Johnston, plants in flower ; pasture, Smoogro, Orphir, Mainland, 18th June 1877, H. H. Johnston, plants in flower ; Reference No. 199, pasture, 80 feet above sea-level, Bu, Hoy, 16th June 1914, H. H. Johnston, rare, plants in flower ; Reference No. 237, marsh, 250 feet above sea-level, North Dam, Orgill, Hoy, 27th June 1914 (plants in full flower), and 3rd September 1914 (plants in fruit), H. H. Johnston, common ; Reference No. 1913, marshy hillside, 380 feet above sea-level, near the source of the Burn of Lushan, Birsay, Mainland, 27th July 1922, H. H. Johnston, plants in full flower ; Reference Nos. 1915 and 2163, grassy banks at roadside, 110 feet above sea-level, Fursan, Evie, Mainland, 28th July 1922 (plants in full flower), and 5th October 1922 (plants in unripe fruit), H. H. Johnston, common ; Reference No. 2389, marsh, 30 feet above sea-level, Lakequoy, Fara, North Isles, 5th July 1923, H. H. Johnston, one plant, in flower, only seen by me ; Reference No. 2502, swamp at burnside, 10 feet above sea-level, Cairston Mill Burn, near its mouth at Hamla Voe in Stromness Harbour, Garson, Stromness, Mainland, 20th June 1924, H. H. Johnston, common, plants in full flower ; Reference No. 2537, marsh, 30 feet above sea-level, Aith, Loch of Skail, Sandwick, Mainland, 26th June 1924, H. H. Johnston, rare, plants in full flower ; Reference No. 2601, marsh, 235 feet above sea-level, near the Burn of Selta on its south side, Stromness, Mainland, 8th July 1924, H. H. Johnston, common, plants in full flower ; Reference Nos. 2611 and 2612, marsh at burnside, 280 feet above sea-level, Burn of Syradale, Firth, Mainland, 11th July 1924, H. H. Johnston, rare, plants in full flower ; and Reference No. 2617, marsh, 140 feet above sea-level, Syradale, Firth, Mainland, 11th July 1924, H. H. Johnston, common, plants in full flower. Native at all these stations in three different islands. Confirms Dr. G. Claridge Druce's record of this variety from Orkney (no station mentioned) in "Bot. Exch. Club Secretary's Report for 1920," vol. vi, part i, p. 48 (September 1921). See *ibid.* "Report for 1922," vol. vi, part v, p. 747 (May 1923), where Dr. G. Claridge Druce has recorded my specimens of Reference No. 1913 from near the

source of the Burn of Lushan, Birsay, Mainland, under the type of the species *ORCHIS PRAETERMISSA*, *Druce*.

ORCHIS PURPURELLA, *T. et. T. A. Stephenson*, in "Journ. Bot.," vol. lviii, pp. 164-170 (July 1920) (*vide* T. Stephenson, various dates between 2nd July 1923 and 12th March 1925).—Reference Nos. 220 and 220 A, marsh, 220 feet above sea-level, South Dam, Hoy, 22nd June 1914 (plants in flower), and 3rd September 1914 (plants in fruit), H. H. Johnston, very rare; Reference No. 647, marsh, 20 feet above sea-level, south of the Established Church Manse, Cross, Sanday, 27th May 1920, H. H. Johnston, plants sparingly in flower; Reference Nos. 1147 and 1520, marshy lochside, 28 feet above sea-level, Kierfield, Loch of Skaill, Sandwick, Mainland, 1st June 1921 (plants in flower), and 4th October 1921 (plants in fruit), H. H. Johnston, common; Reference No. 1181, marshy burnside, 200 feet above sea-level, Quendale, Rousay, 15th June 1921, H. H. Johnston, common, plants in full flower; Reference No. 1190, marsh, 15 feet above sea-level, north end of Loch of Wasbister, Rousay, 16th June 1921, H. H. Johnston, common, plants in full flower; Reference No. 1218, marshy lochside, 325 feet above sea-level, south-east end of Muckle Water, Rousay, 18th June 1921, H. H. Johnston, rare, plants in full flower; Reference No. 1683, marsh, 10 feet above sea-level, Loch of the Graand, Egilsay, 6th June 1922, H. H. Johnston, rare, one plant, in flower-bud, only seen by me; Reference Nos. 1803 and 1804, grassy banks at seashore, 10 feet above sea-level, Kirka Taing, Fara, South Isles, 3rd July 1922, H. H. Johnston, common, plants in full flower; Reference Nos. 2270 and 2271, moist, natural pasture at burnside, 30 feet above sea-level, Mill Burn of Ireland, Stenness, Mainland, 15th June 1923, H. H. Johnston, common, plants sparingly in flower; Reference No. 2311, marshy side of a small streamlet, near the Established Church, west side of Mill Bay, Stronsay, 25th June 1923, H. H. Johnston, rare, plants in flower; Reference Nos. 2516, 2596, and 2599, marsh, 230-235 feet above sea-level, near the Burn of Selta on its south side, Stromness, Mainland, 23rd June 1924, and 8th July 1924 (plants in full flower on both dates), H. H. Johnston, rare; Reference Nos. 2523 and 2524, moist, natural pasture at seashore, 15 feet above sea-level, Garson, Bay of Sandside, Graemsay, 25th June 1924, H. H. Johnston, rare, plants in

full flower ; Reference No. 2528, marsh near seashore, 15 feet above sea-level, Quoys, Bay of Sandside, Graemsay, 25th June 1924, H. H. Johnston, rare, plants in full flower ; Reference No. 2530, marsh, 30 feet above sea-level, Aith, Loch of Skaill, Sandwick, Mainland, 26th June 1924, H. H. Johnston, common, plants in full flower ; Reference Nos. 2613 and 2614, marsh at burnside, 280 feet above sea-level, and marsh, 200 feet above sea-level, respectively, Burn of Syradale, Firth, Mainland, 11th July 1924, H. H. Johnston, rare, plants in full flower ; and Reference No. 2678, marshy heath, 60 feet above sea-level, north side of Thomson's Hill, Fara, South Isles, 30th July 1924, H. H. Johnston, one plant, in flower, only seen by me. Native at all these stations in seven different islands. Confirms Dr. G. Claridge Druce's record of this species from Orkney ("Kirbister," Orphir, Mainland, 3rd August 1920 ; and "Syradale," Firth, Mainland, 6th August 1920), in "Bot. Exch. Club Secretary's Report for 1921," vol. vi, part iii, p. 399 (September 1922). See *ibid.* "Report for 1922," vol. vi, part v, p. 747 (May 1923), where Dr. G. Claridge Druce has recorded my specimens of Reference Nos. 1803 and 1804 from Kirka Taing, Fara, South Isles, under "*O. PURPURELLA* Steph. \times *MACULATA*," but I did not see any plants of *ORCHIS MACULATA*, *Linn.*, *subspecies* *ERICETORUM*, *Linton*, growing in Fara during my two visits to that island on 3rd July 1922 and 30th July 1924.

ORCHIS MACULATA, *Linn.*, *subspecies* *ERICETORUM*, *Linton* \times *ORCHIS PRAETERMISSA*, *Druce*, *var.* *PULCHELLA*, *Druce* (*vide* T. Stephenson, 24th June 1924, 15th July 1924, and 12th March 1925).—Reference Nos. 460, 537, and 2618, marsh, 140 feet above sea-level, Syradale, Firth, Mainland, 1st July 1919 (plants in full flower), 6th September 1919 (plants in unripe fruit), and 11th July 1924 (plants in full flower), H. H. Johnston, rare ; and Reference Nos. 2501 and 2503, swamp at burnside, 10 feet above sea-level, Cairston Mill Burn, near its mouth at Hamla Voe in Stromness Harbour, Stromness, Mainland, 20th June 1924, H. H. Johnston, rare, plants in full flower. Native at these ten stations in the same island. Confirms Dr. G. Claridge Druce's record of this hybrid from Orkney ("Kirbister," Orphir, Mainland, 3rd August 1920, and "Syradale," Firth, Mainland, 6th August 1920), in "Bot. Exch. Club

Secretary's Report for 1921," vol. vi, part iii, p. 399 (September 1922).

ORCHIS MACULATA, *Linn.*, subspecies ERICETORUM, *Linton* × ORCHIS PURPURELLA, *T. et T. A. Stephenson* (*fide* T. Stephenson, various dates between 28th June 1924 and 12th March 1925).—Reference Nos. 1854, 2521, and 2522, moist, natural pasture at seashore, Garson, Bay of Sandside, Graemsay, 13th July 1922 (plants in full flower), and 25th June 1924 (plants in full flower), H. H. Johnston, rare; Reference No. 2272 ("probably" this hybrid), moist, natural pasture at burnside, 30 feet above sea-level, Mill Burn of Ireland, Stenness, Mainland, 15th June 1923, H. H. Johnston, rare, plants sparingly in flower; Reference Nos. 2529 and 2530 A, marsh, 30 feet above sea-level, Aith, Loch of Skaill, Sandwick, Mainland, 26th June 1924, H. H. Johnston, common, plants in full flower; Reference No. 2598, marsh, 230 feet above sea-level, near the Burn of Selta on its south side, Stromness, Mainland, 8th July 1924, H. H. Johnston, one plant, in flower, only seen by me; and Reference Nos. 2614 A and 2615, marsh, 200 feet above sea-level, Burn of Syradale, Firth, Mainland, 11th July 1924, rare, plants in full flower. Native at all these stations in two different islands. A new record for this hybrid for H. C. Watson's county No. 111 Orkney, first discovered by me on 13th July 1922, provided my specimens of Reference Nos. 1803 and 1804 from Kirka Taing, Fara, South Isles, are accepted as ORCHIS PURPURELLA, *T. et T. A. Stephenson* (*fide* T. Stephenson), and not as this hybrid, as recorded by Dr. G. Claridge Druce in "Bot. Exch. Club Secretary's Report for 1922," vol. vi, part v, p. 747 (May 1923). See my remarks on this subject under ORCHIS PURPURELLA, *T. et T. A. Stephenson*, on page 165 of this paper.

HABENARIA VIRIDIS, *R. Brown*, var. OVATA, *Druce* (*fide* G. C. Druce, 27th December 1922).—Heath, west of the Standing Stones of Stenness (named the "Stone Circle of Brodgar" in 1-inch Ordnance Map published in 1912), Stenness, Mainland, 8th August 1881, H. H. Johnston, plants in full flower; hilly pasture, Brockan, Sandwick, Mainland, 23rd July 1886, H. H. Johnston, plants in full flower; Reference No. 277, pasture at top of cliffs at seashore, 100 feet, near Backaquoy, north of Castle of Burwick, South Ronaldsay, 20th July 1914, H. H. Johnston, rare, plants in

full flower; and Reference No. 2143, natural, grassy, heathery pasture, 90 feet above sea-level, Black Craig, Stromness, Mainland, 21st September 1922, H. H. Johnston, one plant, in flower, only seen by me. Native at all these stations in two different islands. Confirms Dr. G. Claridge Druce's record of this variety from Orkney ("Standing Stones of Stenness"), in "Bot. Exch. Club Secretary's Report for 1920," vol. vi, part i, p. 149 (September 1921).

POTAMOGETON PECTINATUS, *Linn.*, var. DIFFUSUS, *Hagström*, form LONGIPEDUNCULATUS, *Tiselius* (*fide* Arthur Bennett, 15th October 1924).—Reference No. 2735, mud at bottom of slightly brackish water, 4 feet deep, in a loch at sea-level, north-west end of Loch of Stenness, Stromness, Mainland, 15th August 1924, H. H. Johnston. Native. Common. Plants in full flower.

POTAMOGETON PECTINATUS, *Linn.*, var. DIFFUSUS, *Hagström*, form PROTENSUS, *Wallroth* (*fide* Arthur Bennett, 15th October 1924).—Reference Nos. 2731 and 2813, mud at bottom of slightly brackish water, 1½ foot deep, in a loch at sea-level, Bay of Voy, north-west end of Loch of Stenness, Stromness, Mainland, 15th August 1924 (plants sparingly in flower-bud), and 15th September 1924 (plants in unripe fruit and sparingly in flower), H. H. Johnston, native, rare; and Reference No. 2814, mud at bottom of slightly brackish water, 5 feet deep, in a loch at sea-level, bay on north-east side of The Ness, Voy, Loch of Stenness, Sandwick, Mainland, 15th September 1924, H. H. Johnston, native, common, plants in fruit and sparingly in flower.

POTAMOGETON POLYGONIFOLIUS, *Pourr.*, var. AMPHIBIUS, *Fries* (*fide* Arthur Bennett, 15th October 1924).—Reference No. 2570, mud at bottom of water, 2 inches deep, in a marsh below a spring of water, 390 feet above sea-level, north side of Mid Hill, Evie, Mainland, 3rd July 1924, H. H. Johnston. Native. Rare. Plants in flower-bud. A new record for this variety for H. C. Watson's county No. 111 Orkney, discovered by me on 3rd July 1924.

AGROSTIS ALBA, *Linn.*, var. b. STOLONIFERA (*Linn.*) *Blytt*. (*fide* Arthur Bennett, 18th October 1924).—Reference No. 2368 B, marsh, 10 feet above sea-level, east side of Rusk Holm, 3rd July 1923, H. H. Johnston. Native. Common. Plants not in flower or fruit, but one plant, taken up with its

roots by me on 3rd July 1923 and planted in a garden at Stromness Town in Mainland, produced numerous stolons rooting at the nodes, flowered from July to September 1924, and produced fruit in September 1924. Confirms the record of this variety from Orkney ("moist pastures") in Neill, "Tour," p. 184 (1806). See Dr. A. R. Duguid's manuscript "Flora Orcadensis" (1858); "Scot. Nat.," No. II.—New Series, p. 74 (October 1883); "Annals Scot. Nat. Hist.," No. 33, p. 38 (January 1900); and Spence, "Flora Orcadensis," p. 86 (1914).

[*Hordeum distichum*, Linn. (*vide* C. E. Hubbard).—Reference No. 2751, oat-field, 290 feet above sea-level, Overabist, Hill-side, Birsay, Mainland, 25th August 1924, H. H. Johnston. Not native. Common among the oats. Plants in young unripe fruit, and grown from barley seeds mixed with oat seeds introduced into Orkney and sown at Overabist, in April 1924, by Mr. John Spence.]

CLASS III.—CRYPTOGAMS.

EQUISETUM UMBROSUM, Meyer [=EQUISETUM PRATENSE, *Ehrh.*] (name confirmed by C. H. Wright in February 1925).—Reference No. 1215, wet grassy and heathery banks at lochside, 325 feet above sea-level, south-west side of Muckle Water, near the north-west end of the loch, Rousay, 18th June 1921, H. H. Johnston. Native. Rare. Sterile stems, 7–10 inches high, only seen by me. My two herbarium specimens are very fine ones and *typical* of this species. On visiting the Muckle Water on 25th May 1922, I found young sterile stems only, and on revisiting the same station on 6th May 1925, I saw no sign of the plants appearing above ground—spring being late and cold in Orkney this year. I have, therefore, not seen any fertile stems of this plant in Orkney. A new record for this species for H. C. Watson's county No. 111 Orkney, discovered by me on 18th June 1921. The record of EQUISETUM PRATENSE, *Ehrh.*, from Orkney, in "Annals Scot. Nat. Hist.," No. 67, p. 170 (July 1908), by Mr. Arthur Bennett, and in Spence, "Flora Orcadensis," p. 97 (1914), rests on a single, small, sterile stem of an EQUISETUM, 6 inches high, collected by the late Mr. Magnus Spence in Deerness, Mainland, in 1907. This specimen, and another sterile stem of the same

gathering, 10 inches high (which latter Mr. Arthur Bennett has seen but did not name), were submitted by me to Kew, where Mr. C. H. Wright wrote the following note on them on 27th January 1921 :—" Both specimens belong to *Equisetum pratense*, Ehrh." On 19th August 1916 the late Mr. Magnus Spence personally showed me the exact spot where this *EQUISETUM* grew in natural, damp, grassy, shell-sandy pasture near the seashore, 30 feet above sea-level, Links of the Hall of Sands, Deerness, Mainland, and I collected several specimens of it, my Reference No. 388, which consist of sterile stems only. One of these specimens I submitted to Mr. C. H. Wright, who named it "*EQUISETUM PRATENSE*, Ehrh.," on 27th January 1921 ; but, on my resubmitting it with more specimens of the same gathering to him, he renamed them all "*EQUISETUM ARVENSE*, Linn.," with which latter determination I entirely agree. The two sterile specimens of *EQUISETUM* collected by the late Mr. Magnus Spence in Deerness, in 1907, have not the remotest resemblance to my *typical* specimens of *EQUISETUM PRATENSE*, Ehrh., from Rousay, and I have no hesitation in regarding them both as a form of *EQUISETUM ARVENSE*, Linn., which is common in sandy links near the seashore in different parts of Orkney. I visited the Links of the Hall of Sands in April, May, and June 1922, but I saw no fertile stems of either of the above-mentioned two species growing there ; and the only species of *EQUISETUM* I have seen growing on these links are *EQUISETUM ARVENSE*, Linn., with sterile stems only, and *EQUISETUM PALUSTRE*, Linn., with both young fertile and sterile stems, on 10th May 1921. See "Trans. Bot. Soc. Edin.," vol. xxviii, part ii, p. 64 (1921), as corrected from "*EQUISETUM PRATENSE*, Ehrh.," to *EQUISETUM ARVENSE*, Linn., in *ibid.*, vol. xxix, part i, p. 85 (1924).

EQUISETUM SYLVATICUM, Linn., *var. SEROTINUM*, Milde.—Reference No. 1977, heathery banks at burnside, 300 feet above sea-level, Naversdale Burn, Orphir, Mainland, 12th August 1922, H. H. Johnston. Native. Rare. Sterile stems only seen by me. A new record for this variety for H. C. Watson's county No. 111 Orkney, discovered by me on 12th August 1922. My specimen agrees exactly with a specimen of this variety, collected by Mr. Selim Birger in Södennanland, Scandinavia, on 26th August 1923, and communicated to me by Dr. Hj. Möller, Stockholm, Sweden.

CHARA DELICATULA, *Agardh*, var. c. ANNULATA, *Groves et Bullock-Webster*, in "The British Charophyta," vol. ii, pp. 68-69, plate xlv, figures 10-11 (1924).—Rocky, muddy bed at bottom of nearly fresh water in a loch near the sea-level, Holms of Wasbister, Loch of Harray, Sandwick, Mainland, 8th August 1881, H. H. Johnston. Native. Confirms the record of this variety from Orkney ("L. of Harray") in *Groves and Bullock-Webster*, "The British Charophyta," vol. ii, p. 69 (1924).

NOTES ON STRAND PLANTS. I. *ATRIPLEX BABINGTONII*,
WOODS. By NORAH M. CUMMING, B.Sc.

(Read 19th June 1925.)

Atriplex Babingtonii, a member of the Strand Association, is a low-growing annual herb. The soil in which the plant grows is hot and dry, has a low-water content, and is distinctly alkaline, the P_H value determined colorimetrically being 8. The plant juices give a P_H value of 6.5, *i.e.* actively acid, explained by the high percentage of oxalates present and correlated to the occurrence of anthocyanin.

The plant has a well-developed tap root like a pivot, from which the much-branched prostrate leafy stems radiate out in a rosette. The apices of the branches curve upwards and end in spicate inflorescences. At the base of the stem the internodes are alternately long and short; the phyllotaxy is cyclic, while in the younger areas it is spiral.

LEAF.

The young leaves are apetiolate, with an entire margin and acuminate apex, gradually changing shape with age through ovate and cordate to hastate. Concurrent with this change in shape occurs the gradual development of a petiole which is flattened and winged, and in its most highly developed condition is only slightly longer than it is broad. In orientation the leaves are sub-erect, with a slight apical inward curvature. The venation is pinnate-reticulate.

The green colour is veiled by a white powdery substance which is found on both surfaces of the leaf, but is most abundant on the under side which, owing to the upward and inward curvature, is the more exposed. The white powder is a xerophilous device in relation to the dry habitat of the plant.

INTERNAL ANATOMY.

Crystals of oxalate never occur in the epidermal cells, which, however, contain anthocyanin in weak concentration

insufficient to give a red coloration appreciable on external inspection.

The white powdery appearance is due to the presence of bicellular capitate hairs. The diameter of the heads of the hairs on the under surface is about twice that of those on the upper. They are also more numerous; hence the under is the better protected area.

In the young leaves, owing to the fully distended heads which overlap in consequence of the varied lengths of the stalks, a chamber is formed between the surface of the leaf and the approximated heads, opening by occasional small intervals. With age the hairs dry, wither, undergo distortion, so that the heads becoming sinuous form a complete covering. As drying continues mutual pressure is set up, and the heads of the hairs ultimately becoming detached form a white powder.

The vacuoles of the head cells are rich in oxalates, either in solution or deposited rarely as rhombic crystals. Sodium chloride also occurs, but crystallises out on the walls with age; osmotic pressure is thus reduced and diffusion is facilitated.

Normal stomata flush with the epidermis occur on both surfaces of the leaf, but are more numerous on the upper, which is the least exposed.

Hydathodes are present on the under surface of the long acuminate apices of the young leaves. These have no epithem, nor have the pores any relation to the ends of the vascular bundles. They are larger than the normal stomata, and occupy two lines flanking and almost parallel to the single vascular strand for a length of one millimetre of the leaf tip, .6 millimetre from the actual apex.

The structure of the mesophyll agrees with that described and figured by Solereder (1) for *Atriplex hastata*, in its differentiation into superficial aqueous and central palisade tissue and in the total absence of spongy tissue. Rhombic and compound crystals of calcium oxalate occur either singly or in pairs in the aqueous cells. They are more abundant towards the upper surface of the leaf, *i.e.* opposite the xylem elements of the meristeles.

The xylem of the meristeles is composed of spiral tracheids and wood parenchyma, the phloem of rectangular prismatic cells intermixed with larger cylindrical elements having no sieve-plates.

STRUCTURE OF THE PETIOLE.

The epidermis of the short broad petiole of the adult leaf is heavily cutinised. Stomata similar to those of the lamina occur on the flanks overarched by the lateral wings.

There is a collenchymatous hypoderma one to two cells deep, broadening out at the corners to give strands five cells deep.

The vascular system of the petiole consists of five or seven closed collateral bundles in a plane almost parallel to the upper surface and embedded in uniform ground tissue.

Oxalates in rosette crystals occur in the parenchyma cells above and below the meristele: on the lower side chiefly in the third layer from the phloem, on the upper in four rows of cells in gradually centrifugally diminishing amount.

ORIGIN AND COURSE OF THE LEAF TRACES.

Three vascular bundles from the primary stelar ring of the stem pass out to each leaf either directly or after dividing once or twice in the cortex. The second case is the most common. Here the five meristeles have an almost parallel course throughout the petiole, and passing into the lamina form the five prominent veins. Within the lamina the lateral meristeles branch, giving a typical pinnate-reticulate venation with a sympodial bundle a tenth of a millimetre from the leaf margin. Certain of its branches with free ends are directed towards the marginal teeth, but the latter have no water pores.

The central bundle of the mid-rib for about one-half of its length is flanked by laterals, with which, however, it has no direct connection. It runs to the tip of the leaf, branching freely in its upper half, and forms the main channel by means of which water is transported to the hydathodal region.

STEM.

The surface of the stem is finely ridged and furrowed, the ridges being red in colour, the furrows green.

The epidermis is one cell deep; on the ridges it consists of cells elongated parallel to the long axis with either horizontal or interpectinating end walls. Stomata are confined to the furrows, and the adjacent epidermal cells are isodiametric.

The protection of the stomata is more efficient than in the leaf, owing to their position in the furrows and to the larger proportion of hairs covering them.

Opposite the ridges are strands of collenchyma two to three cells deep. These cells contain anthocyanin, which gives the red colour apparent externally. Alternating with the collenchyma strands are strands of palisade-like chlorenchyma cells. The inner cortex is of colourless parenchyma cells increasing in size centripetally. The innermost layer is a starch sheath and contains anthocyanin. The layer external to this is crystallogenous, while several of the adjacent cortical cells contain oxalates in solution; and the phloem parenchyma, crystal sand. As in the leaf, the crystallogenous tissue is in close proximity to the vascular bundles. In the stem, crystals are more abundant in the tissue opposite the phloem; in the leaf, opposite the xylem.

Surrounding the stele is a one-layered pericycle of small thin-walled cells. The primary stele consists of a ring of open collateral bundles separated by wide medullary rays and surrounding a parenchymatous pith, which contains a limited number of crystallogenous sacs.

SECONDARY CHANGES IN THE STEM.

There is no cork formation in the old stem, but the epidermis is persistent. There is now a continuous hypoderma of collenchyma, and for the starch sheath is substituted a continuous cylinder of collenchyma two to three cells deep opposite the ridges, and one cell deep elsewhere. Later, the crescents of collenchyma opposite the bundles are transformed into strands of sclerenchyma, whose position is in nowise related to the external ridging of the stem.

A limited amount of normal secondary thickening occurs, and the radial extensions of the primary medullary rays so formed are of lignified prosenchyma.

ANOMALOUS SECONDARY GROWTH OF THE STEM.

This is effected by a series of cambiums formed first from the pericycle and later from the phloem. As a result of the anomalous growth, a cylinder of lignified tissue in which lie

irregularly scattered vascular bundles is formed (fig. 1). The first cambium is extrafascicular, and originates in the parenchy-

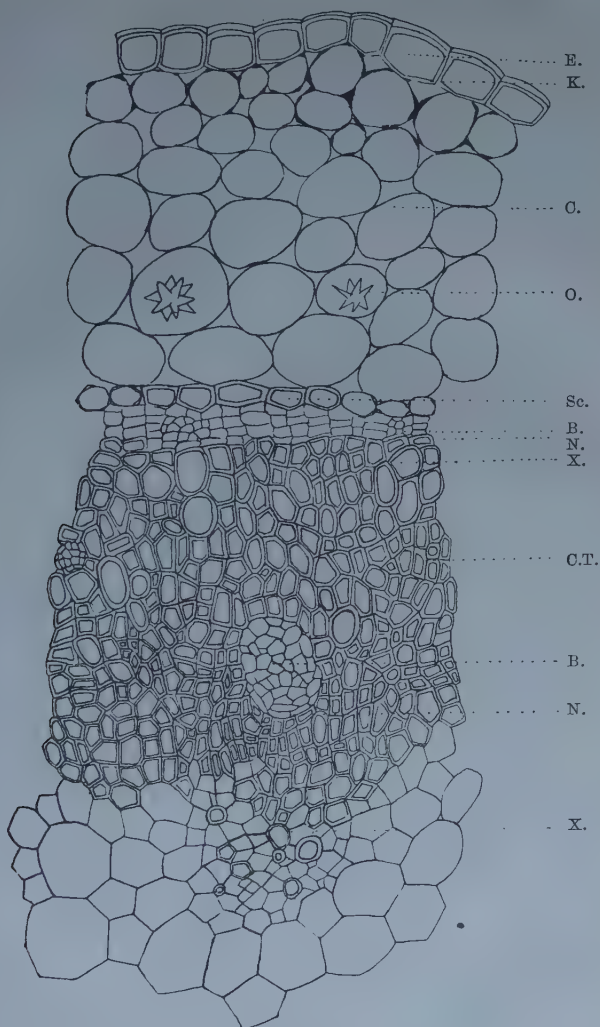


FIG. 1.—Transverse section of stem showing secondary structure: A, aqueous tissue; B, phloem; C, inner cortex; D, endodermis; E, epidermis; K, collenchyma; L, palisade; M, metaxylem; N, cambium; O, oxalate crystal; P, protoxylem; R, pericycle; S, sheath; X, xylem; C.T., conjunctive tissue; Sc., sclerenchyma.

matous pericycle on the inner side of the sclerenchyma fibres. By tangential divisions in a centrifugal direction it lays down

a belt of lignified conjunctive tissue. Thereafter at irregular intervals it forms radial rows of xylem elements embedded in prosenchyma, and also laid down centrifugally. Corresponding patches of phloem are afterwards formed by centripetal divisions. With the formation of the phloems the activity of the cambium in the phloem area ceases, and a new cambium is organised on the outer periphery of the phloem patch, while to right and left of it the previously formed cambium, remaining active, continues to form lignified conjunctive tissue. In this way the cambium ring is always complete, but its various segments do not have a common origin. By its activity it gives rise to a cylinder of lignified tissue, in which appear scattered islands of phloem in connection with which are the only parenchymatous elements of the secondary growth. The lignified tissue consists of the xylem portions of the scattered collateral bundles, and conjunctive tissue separating them in radial and tangential direction. The activity of the cambium is limited, and not more than two anomalous bundles are formed on any one radius. Before finally ceasing its activity the cambium cuts off a few layers of parenchyma in a centripetal direction. The parenchymatous cylinder, in which are embedded the phloems of the last-formed anomalous bundles, is formed at a slower rate than the conjunctive tissue. Thus, owing to the more rapid centrifugal growth of the harder tissues, it tends to be crushed between them and the sclerenchyma strands, while at the same time it is subjected to a tensile strain, causing tangential stretching of the cells.

Occasionally at the beginning of its activity the extrafascicular cambium, instead of forming lignified prosenchyma, gives rise to parenchyma, while the radial extensions of the primary rays formed by the normal cambium are also parenchymatous. The primary bundles are then surrounded by parenchyma, and they appear medullary.

The first divisions of the cambium to give phloem are by tangential walls. The mother cells thereafter divide by longitudinal walls in various planes. The phloem elements are thus not arranged in radial rows but irregularly, and vary in size and shape. The phloem is very largely of parenchyma, but contains a few sieve-tubes isolated or in small groups and having no companion cells.

The elements of the xylem and conjunctive tissue are formed by divisions in a tangential direction only, and are therefore arranged radially. The conjunctive tissue is of two kinds of prosenchyma. There are elongated spindle-shaped cells with interpectinating, and shorter elements with transverse, end-walls. The latter are found in connection with the xylem of the secondary bundles. The xylem is of spiral and simple pitted vessels and tracheids. The vessels frequently contain large numbers of rhombic and irregular crystals.

Root.

The primary stele of the root is diarch and non-medullated. There is a two-layered pericycle of thin-walled cells, and a typical endodermis. The cortex is of parenchyma, and contains no crystal sacs. Soon after the commencement of secondary growth in the stele, a phellogen of limited activity arises in the pericycle and produces a phelloderm and phellem. The latter, owing to subsequent active growth of the stele, is ruptured at intervals, while the phelloderm is stretched tangentially.

A limited amount of normal secondary growth is brought about by a cambium which originates between the central plate of xylem and the primary phloems, but is not continued round the poles of the xylem.

The further growth is anomalous, and is brought about by a series of cambiums, the first of which, as in the stem, arises in the inner layer of the pericycle, while the successive later cambiums originate in the previously formed anomalous phloems. The whole of the pericycle is thus used up in meristematic activity, the outer layer giving the phellogen, the inner the extrafascicular cambium. The activity of the anomalous cambium is limited, and alternating concentric zones of lignified tissue centrifugally formed and centripetal parenchyma are laid down. Each cambium gives rise to four strata: (1) A considerable belt of conjunctive tissue of lignified prosenchyma cells radially arranged; (2) a zone of similar conjunctive interrupted at intervals by radial rows of vessels; (3) a ring of phloem groups corresponding in position to the previously formed xylems, and separated in a tangential direction by parenchyma; (4) a narrow zone of

parenchyma. The formation of the first two strata is almost complete before the latter two begin to be formed. With the formation of the fourth zone the activity of the cambium ceases. A new cambium arises in the periphery of the parenchymatous ring (zone 4), and, as before, first a ring of lignified tissue, and then a ring of parenchyma in which collateral vascular bundles can be distinguished, is formed.

In the oldest root there may be five successively formed cambiums. In some cases, in one or more parts of the ring the cambium does not form parenchyma while this formation is taking place to left and right, but it continues to form lignified tissue in shape of a bridge of loose spongy tissue, after the formation of which the cambium does not die but proceeds to form the next lignified zone. Thus, as in the stem, the cambium ring, although always complete, is not all of the same origin. Over limited areas a previously formed cambium remains active, while to right and left of it, the activity of this cambium being closed by the formation of parenchyma, a new cambium arises from the ground tissue formed by the cambium which has just ceased activity.

The xylem of the anomalous bundles is of reticulate and pitted vessels and pitted tracheids. The phloem consists almost entirely of sieve-tubes with no companion cells, contrary to the statement of De Bary (2). They have relatively short members, the end walls of which may be horizontal or oblique. Sieve-plates with callus occur on these end walls, and also occasionally on the radial walls. The normally formed secondary phloem is largely of parenchyma, in which are a few isolated sieve-tubes.

THE SEEDLING.

Of seeds collected at the end of January and immediately planted, twelve out of thirteen showed viability. The germination is epigeal, and the seed is carried up on the tip of the cotyledons. The seeds were placed in an incubator at 33° C., and germinated on the average in thirty-eight hours.

EXAMINATION OF THE NINE DAYS OLD SEEDLING.

The average length of the seedlings from the tip of the root to the point of attachment of the cotyledons is 9 cm.

Cotyledon.

The cotyledons are linear (average dimensions $1.6 \times .4$ cm.) and orientated horizontally. The basal half chiefly in the mid-rib region contains anthocyanin, which generally appears on the fifth day after germination.

The epidermis differs from that of the adult leaf in bearing no hairs and in possessing a higher concentration of anthocyanin in the sap vacuoles. The concentration is greatest near the mid-rib on the upper surface, gradually becoming less towards the margins and under surface.

The mesophyll resembles that of the adult leaf in its differentiation. The aqueous tissue towards the tip of the cotyledon grades into a tissue of cells of irregular shape with rich protoplasmic contents and relatively large nuclei. This tissue in conjunction with the epidermal covering, which in this area consists of cells with relatively small vacuoles, probably has a haustorial function.

The central meristele at the base of the cotyledons at this stage is not a single bundle but a triad consisting of two bundles, the phloem patches of which are quite distinct and not directly below the corresponding metaxylems, but showing slight lateral displacement outwards. The xylem patches are in contiguity, and lying between the two metaxylems is a common protoxylem directed towards the upper surface of the leaf (fig. 2 (3)). Towards the apex of the leaf the two bundles converge so as to form a single collateral bundle. The two phloem patches have rotated and come together in the normal position, while the common strand of protoxylem has died out.

THE HYPOCOTYL OF THE NINE DAYS OLD SEEDLING.

The surface of the hypocotyl is not furrowed like the adult stem, and it bears no hairs or stomata. The epidermis, the three successive layers of cortex, and the endodermis all contain anthocyanin, the concentration of which is proportional to the concentration of glucosides in these cells. Starch is present in large quantity in the endodermis, and there is a centrifugal diminution in the number of granules in the successive layers of the cortex, the two outermost layers and

the epidermis containing none. In the nine days old seedling

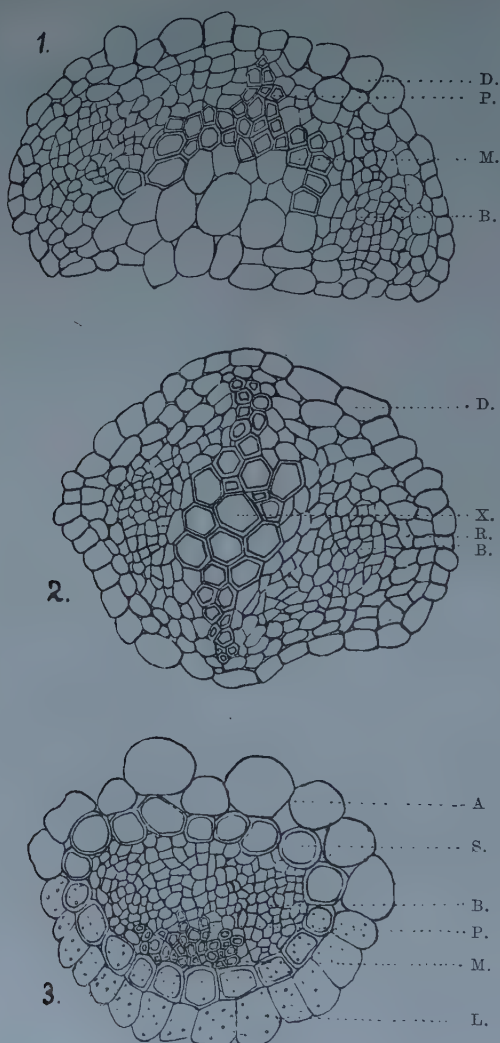


FIG. 2.—(1) Transverse section of hypocotyl (3 cm. from ground-level) showing triad structure.
 (2) Transverse section of primary root showing diarchy.
 (3) Transverse section of base of cotyledon with triad structure. Lettering as in fig. 1.

calcium oxalate is found in the form of rhombic crystals of rare distribution, but when the seedling is fourteen days old

sphaerite crystals are found in almost every cell of the cortical layer outside the endodermis.

It is noteworthy that anthocyanin is never found in the root proper, even when growing exposed to the light, although the pigment may develop in the hypogeal part of the hypocotyl and in the plumule while still enclosed between the erect cotyledons.

THE STELAR STRUCTURE OF THE ROOT AND HYPOCOTYL, AND THE TRANSITION REGION IN THE NINE DAYS OLD SEEDLING.

On sectioning the radicle (meaning the primary root and the hypocotyl) from below upwards, the following stages are seen. The colourless part has a normal root structure with a central solid diarch strand of xylem flanked by two patches of phloem (fig. 2 (2)). In a section just below the level where anthocyanin first appears, two lateral protrusions appear on the central xylem strand by the formation of new elements between it and the phloem patches. These are diagonally placed, and shortly after their appearance another pair of similar protrusions form in the opposite diagonal plane. Thereafter medullation begins to take place. The central vessels of the metaxylem become separated by a few parenchymatous cells, and as growth of parenchyma takes place in a plane at right angles to the diametric xylem, each phloem patch is divided into two. The four smaller phloem patches are thus antiposed to the protrusions of metaxylem already referred to. At this stage the stele consists of two opposite patches of exarch xylem, each of which is flanked by two collateral bundles at right angles to it, the xylem of the latter consisting of new metaxylem, while the phloem is contributed by half of the original phloem strand of the root (fig. 2 (1)). This condition is continued throughout about two-thirds of the length of the radicle. New vessels continue to be formed centrifugally, and the phloems begin to rotate through an angle of 90° , the patches originating from one strand in the root thus becoming further removed from each other, until finally two patches from opposite sides come to lie alongside the exarch xylem strand. In this way two bundles are formed at each side, having separate phloems and metaxylems and

a common protoxylem lying between them. This condition is continued throughout the remainder of the hypocotyl, and one of the compound bundles passes into each cotyledon, forming the triad already referred to.

The stele in the fourteen days old seedling is slightly different from that described. The preliminary stages in the transition are as before, but in the upper fifth of the hypocotyl, the protoxylem separating the two bundles of one cotyledonary strand has died out, and the two bundles have coalesced to form the single strand which passes out as the main meristele of the cotyledon. The plumule is supplied by cauline bundles which arise between the cotyledonary bundles just after rotation has been completed. Two bundles arise in each of the rays close to the cotyledonary strand, and the bundles of each pair gradually converge and form a single bundle passing into the plumule (fig. 3 (1-10)).

The structure of the transition region corresponds to that described by Chauveaud (3) in *Atriplex hastata* (L.), differing only in the cauline bundles. Chauveaud describes only one cauline bundle arising in each ray.

The level of the transition conforms to the "intermediate low" type of Compton (4), and the structure of the nine days old seedling corresponds to that described by him in *Lupinus mutabilis*.

The method of rotation may be referred to Type III of Van Tieghem (5); movement of the phloem occurs while the xylem remains fixed. The stelar structure throughout the greater part of the hypocotyl shows the cruciform arrangement described by Thomas (6).

THE PLUMULE.

The plumule does not elongate appreciably until the seedling is two weeks old, but previous to this the young leaves exhibit some of the characters of the adult leaf. Before differentiation of tissues occurs, all the cells of the leaf primordia contain anthocyanin in their small sap vacuoles. This suggests that the pigment is present in the aqueous cells of the adult leaf, but with increase in size of the vacuoles the concentration so diminishes that there is no obvious colour.

Hairs are developed on the leaves at a very early stage, but

differentiation of the mesophyll does not occur until the leaf is exposed to the light by the separation of the cotyledons.

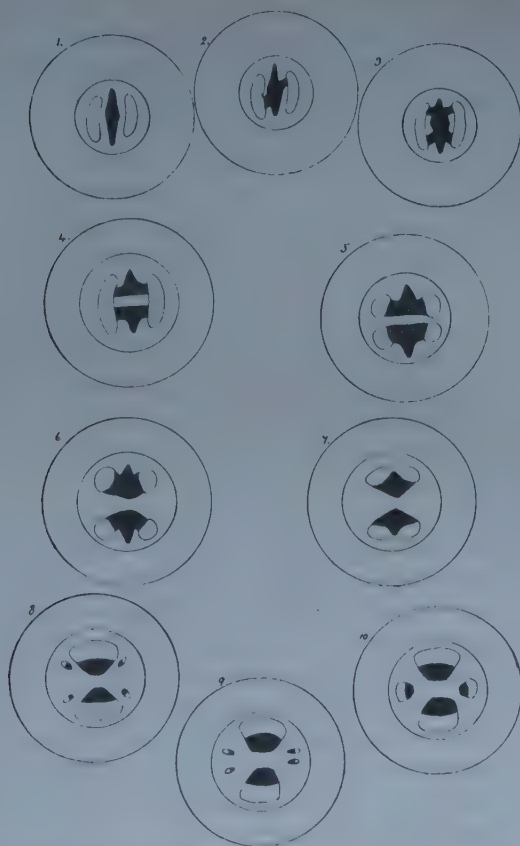


FIG. 3.—Serial diagrams of transition in axis of seedling fourteen days old
 1, normal diarch root structure ; 2, formation of diagonal xylem protrusions ; 3, further formation of new xylem elements ; 4, medullation ; 5, division of the phloems ; 6, commencement of rotation of the phloems ; 7, phloems in contiguity and the protoxylem dying out ; 8, appearance of cauline bundles ; 9, approximation of cauline bundles ; 10, fusion of cauline strands.

STRUCTURE OF THE TRANSITION REGION IN THE ADULT PLANT.

The transition from root to stem structure in the primary stele of the adult plant is comparable to that described for the seedling. Medullation divides the primary stele into two parallel strands, each of which consists of central protoxylem

flanked by bundles which have undergone secondary thickening. The metaxylem of the bundles is in close contiguity with the strand of protoxylem, there being no intermediate cells. Later, the protoxylem dying out, the two bundles on one side approximate each other, giving one cotyledonary strand.

Cauline bundles appear in the primary medullary rays. These increase in size tangentially, so that they occupy almost the whole medullary ray. Secondary growth of the cotyledonary bundles ceases, and, as the pith increases in dimensions, the secondary elements previously formed are displaced from their radial arrangement and are more or less scattered in parenchyma.

There is a marked difference between the anomalous secondary growth of the stele of the stem and the root. In the stem, as the result of the activity of single cambium, the origin of which may vary at different parts of the ring, scattered bundles appear lying in lignified conjunctive tissue, whereas in the root repeated cambiums are formed, giving concentric rings of bundles. The transition from the one type of stele to the other is a gradual one, beginning in the root about an inch below the ground-level, and continued throughout the first three or four internodes of the stem.

Passing from root to stem the cambiums assume a sinuous outline. The lignified bridges referred to in the description of the root become very much wider and more frequent. This is brought about by the continued activity of a cambium over wide areas, while at other parts of the ring, after formation of parenchyma by centripetal divisions, it is replaced by a new cambium. This process ultimately leads to the whole of the rays between the bundles becoming lignified, the only parenchyma elements being in connection with the phloems. The two or three outer cambiums fail to appear in the upper internodes of the transition region, and this, combined with the assumption of a sinuous outline by the cambiums, followed by lignification of the rays, completes the passage to stem structure.

SUMMARY.

1. The leaf possesses xerophilous adaptations in the form of aqueous tissue and epidermal hairs. The former is present in the cotyledons; hairs first appear in the primary leaves.

2. Both the root and the stem show normal secondary thickening to a limited extent. The normal cambium in the root is replaced by successive cambiums, each of limited activity, the whole cambial ring as a rule ceasing activity at the same time. In the stem there is a single extrafascicular cambium, which remains permanently active except where it is used up in the formation of phloem. It is then replaced by a meristematic strip formed in the outer periphery of the phloem.

3. The anomalous growth of the stele of the root consists of concentric zones of lignified and parenchymatous tissue with regularly disposed bundles. In the stem the anomalous bundles are scattered irregularly in prosenchyma.

4. The epidermis of the stem is persistent. Periderm is formed at an early stage in the root.

5. Oxalates occur in the stem and leaf as crystals, crystal sand, and in solution. Crystals are found in tissues in relation to the vascular bundles.

6. Anthocyanin occurs along with glucosides in the epidermis of the leaf, and in the superficial layers and endodermis of the stem. The concentration of anthocyanin is proportional to that of the glucoside. The development of anthocyanin is independent of light.

7. In the nine days old seedling the cotyledonary bundles consist of a triad throughout the greater part of the hypocotyl. In the upper part of the cotyledon the triad is transformed into a single collateral bundle. In the older seedlings this transformation occurs in the upper part of the hypocotyl.

The writer has to express her indebtedness for facilities and assistance afforded her in the Botanical Department, St. Andrews University, where these investigations were carried out.

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NOTE ON AN EXOASCUS DISEASE ON PRUNUS AMYGDALUS
VAR. AMARA. By WILLIAM G. CAMPBELL, B.Sc.

(Read 19th June 1925.)

The effects of this disease have been evident on the leaves and twigs of the specimens of *Prunus amygdalus* var. *amara* in St. Andrews University Botanic Garden for several years. When first noted, the number of diseased members was small, but this has increased considerably from year to year. In the tree under investigation nearly all the foliage leaves and twigs were infected in the summer of 1923. A specimen of *Prunus amygdalus* var. *dulcis* is growing in close proximity to this tree, and the disease has spread to it. A marked increase in the number of diseased members is taking place in the specimen of the *dulcis* variety, so it is to be concluded that both varieties are susceptible.

The diseased tree is easily recognised because of the abnormal appearance of its twigs. These attain a certain size, and then, due to infection, they die back, so that the tree bears an enormous number of dead twigs, which vary in length from 3 to 6 inches. This gives a characteristic appearance to the tree, even in winter. The effects of the fungus on the woody parts are evident even after the leaves appear, as the apical extremities of the branches are devoid of leaves for a distance of about 6 inches from the tips backwards. The parts of the branches which bear no leaves are dry and withered. Signs of disease are particularly obvious, however, in the foliage leaves, where discoloration, hypertrophy, and general deformation of both lamina and petiole are produced.

The leaf of *Prunus amygdalus* var. *amara* is lanceolate, or oblong lanceolate, and petiolate. The margin is obtusely serrate, and at the tip of most of the teeth a gland is present. The mid-rib and secondary veins are pale green in colour and prominent, being grooved on the upper surface and keeled on the under surface. The leaf is glabrous; it is dark green and shiny on the upper surface, but lighter in colour and not so shiny on the under surface.

Differentiation into palisade and spongy mesophyll is well marked, there being two to three layers of the former and

three to four layers of the latter. Intercellular spaces towards the upper surface are small, but they increase in size towards the under surface. All the mesophyll cells are chlorophyllous, and numerous crystallogenous cells are present, each containing a large sphaero-crystal of calcium oxalate. The petiole has a sheathing base, and has a deep groove on the upper surface. From four to six glands are present in pairs on the upper surface at the base of the lamina.

The first indication of infection in the leaves is noted early in May when the leaf buds open. Crimson coloured patches appear on some of the leaves before they open. The upper surfaces of some of the petioles are also involved. The coloured patches are not restricted to any particular part of the leaf's upper surface. They are scattered and variable in size. The colour is present only in the upper epidermal and mesophyll cells.

As the development of the leaves proceeds, the coloured areas increase in size. The leaves which are conduplicate, with only the under surface exposed, now open out. Later, an involution of the margins towards the upper surface takes place, and later still, a marked puckering takes place between the veins, so that in these areas the upper surface is convex, while the under surface is concave. A marked increase in thickness in the diseased areas also occurs (figs. 1 and 2), but this is preceded by the red coloration.

All leaves do not become infected to the same extent, some being wholly and others only partially diseased. In all diseased areas, however, the normal leaf characteristics such as shape, colour, and dimensions are altered. The totally diseased leaf is approximately three times wider and a fifth longer than the normal one. An enormous increase in thickness is also obvious, the diseased lamina being two to five times thicker than the normal one. The diseased petiole is three times as wide at its widest part as the normal one, and the groove on the upper surface is not nearly so well marked. The average weight of the totally diseased leaf is approximately eleven times that of the normal one.

A marked difference in stomatal distribution has been observed. Whereas in the normal leaf there are 160 stomata per sq. mm., in the diseased leaf there are only 80 to 90. This is accounted for by the fact that a large increase in

surface area takes place due to infection. By August all diseased leaves have fallen from the tree and it appears to

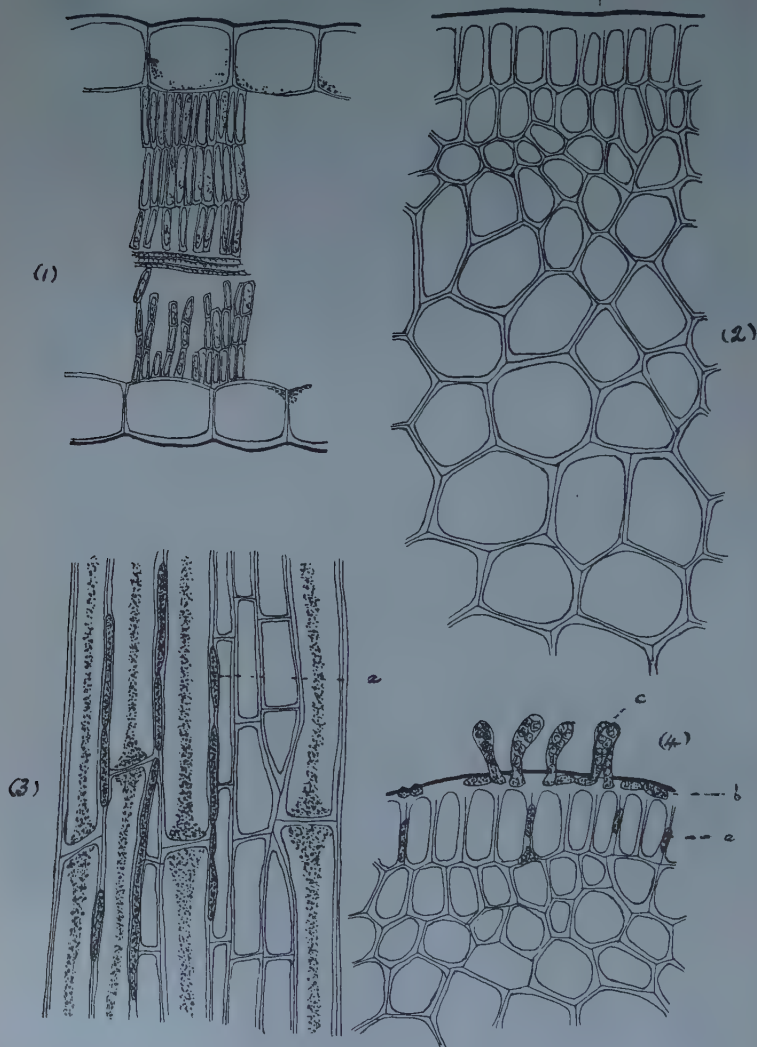


FIG. 1.—Transverse section of fresh leaf, $\times 285$.

FIG. 2.—Transverse section of upper part of diseased leaf, $\times 285$.

FIG. 3.—Longitudinal section of phloem showing fungal hyphae, $\times 465$.

FIG. 4.—Transverse section of diseased leaf, $\times 375$: *a*, fungal hyphae; *b*, subcuticular mycelium; *c*, ascus containing ascospores.

be free from infection, although the crown of foliage is somewhat thin.

Location of the Fungus in the Host, and the Internal Pathological Effects.—The fungus hibernates in the walls of the phloem elements of the shoots (fig. 3). It is thus in close proximity to ample organic food supplies. It has been concluded that the mycelium penetrates the young leaves *via* the phloem. Preparations have been obtained which show that at an early stage hyphae are not discernible in the leaf, although at the same time the crimson coloured patches are present. This would indicate either that the hyphae, if present, are exceedingly small, or that a secretion from the fungus precedes it in the course of infection. At a later stage the hyphae have been observed in the intercellular spaces and between the walls of the upper epidermal and mesophyll cells. Ultimately a subcuticular mycelium is formed, and from it the asci arise. They appear as swellings, increase in size, and ultimately erupt through the cuticle. They are club-shaped and stalkless (fig. 4). This stage is usually reached in June and July, and the leaf now resembles ripe fruit in appearance, as it is of a bright crimson colour and the surface is covered with a "bloom" formed by the closely packed asci.

From six to eight nearly spherical ascospores occur in each ascus, in two vertical rows stretching from apex to base. The asci measure $34 \times 11-12 \mu$ and the ascospores $7 \times 5 \mu$. Conidia have also been observed. When these are formed the ascospores first aggregate at the apex of the ascus, and then divide up into conidia of small size. Ascospores placed in a "hanging drop" culture of Prune decoction early in May germinate in four days.

The fungus produces no chemical changes in the cell-wall materials of its host. The diseased epidermal cell is the same depth as the normal cell, but it is only half as wide. The arrangement of the cells is different in the two leaves (figs. 1 and 2). Whereas in the normal leaf the long axis is parallel, in the diseased leaf it is perpendicular to the surface, so that the cells form a palisade. An increase in thickness of the epidermal cell walls is evident, the outer exposed wall being almost twice as thick. Most of the epidermal cells contain the sap pigment, anthocyanin.

The most outstanding morphological changes take place in the mesophyll (figs. 1 and 2). Differentiation into palisade

and spongy tissue is lost and chlorophyll disappears. Many of the cells contain anthocyanin. They are polygonal in shape and vary in size from $15 \times 20 \mu$ to $25 \times 45 \mu$. The striking feature is the great increase in size of this tissue. Whereas in the normal leaf there are seven layers of mesophyll at the most, in the diseased leaf there are from fifteen to twenty layers. The great size of this tissue is due to proliferation of cells, and also to an increase in the size of the cells themselves. Intercellular spaces are hardly discernible, due probably to their small size and the fact that they are blocked up with hyphae.

Theoretically, two explanations seem probable for the presence of anthocyanin in the diseased leaves. In the first place, with Chodat's theory of the process of oxidation in cells in view, it seems probable that since the intercellular spaces in the upper part of the leaf are blocked up, the molecular oxygen of the atmosphere will be shut off from the upper mesophyll and epidermal cells. If such is the case, the normal action of peroxide and peroxidase will be interfered with. Possibly this interference may result in a reaction whereby the colour is produced. On the other hand, when it is considered that the anthocyan pigments assume a red colour when treated with acids, it is conceivable that an organic acid secreted by the fungus may act upon such a substance, which may be present in the cells in a colourless condition. The sap of the diseased leaf is certainly more acid than that of the normal leaf, the P_H value of the former being 5.5, while that of the latter is between 6 and 6.5.

So far as the involution of the margins and the puckering between the veins are concerned, the direct cause of these phenomena is to be sought in an alteration of the permeability of the plasmatic films. In the former instance, the permeability of the films of cells towards the upper surface must be increased, and as a result, turgescence is greater towards the under surface. More growth then takes place on the under surface. In the case of the puckering between the veins, it is to be concluded that the permeability of the films of cells towards the under surface of these regions increases, with the result that turgescence is greater in cells towards the upper surface and more growth takes place there. The alteration in the permeability of the cell films

must be caused by a chemical change in some of the constituents of the sap, and this change must necessarily be brought about in some manner by the fungus.

According to Tubeuf (1), *Exoascus deformans* (Berk.) causes the "curl disease" of the peach. He also mentions an *Exoascus* which occurs on the almond, and which so resembles *E. deformans* that he regards it as the same species. This contention is supported by the investigations of W. G. Smith (4), who has shown that there is no difference in the pathological effects produced on the twigs of the peach and the almond. The species is also mentioned by Massee (2). Sadebeck (5) in his treatise on the Exoascaceae places *E. deformans* in the class which have a perennating mycelium and whose asci are stalked. Young (3) has recently described a leaf disease of plum caused by *E. mirabilis* (Atk.), whose asci are also stalked.

Evidently the fungus under investigation is not the true *E. deformans*, as it differs from the type in various details. It agrees with the description given by Smith in external characters and habit, except that there is no hypertrophy of the twigs antecedent to death. The asci are also on the upper surface only. Another difference is that the asci have no stalk cell, and the dimensions of the ascospores and asci do not correspond with the figures given by Massee (2). The asci measure $34 \times 11-12 \mu$ and the ascospores $7 \times 5 \mu$. According to Massee, the asci of *E. deformans* measure $40-50 \times 7-8 \mu$ and the ascospores measure $7 \times 3-4 \mu$. The data of spore size given by Pierce (6) also differ. At the same time, the nature of the fungus, its mode of attack, the fact that it hibernates in the phloem walls of its host, and the changes it produces in the host would seem to justify the conclusion that it is a variety of *E. deformans*.

The writer expresses his indebtedness for facilities and assistance afforded him in the Botanical Department, St. Andrews University, where this investigation was carried out.

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"PULL ROOTS" OF *OXALIS ESCULENTA*. By J. FINDLAY
DUNCAN, B.Sc.

(Read 19th June 1925.)

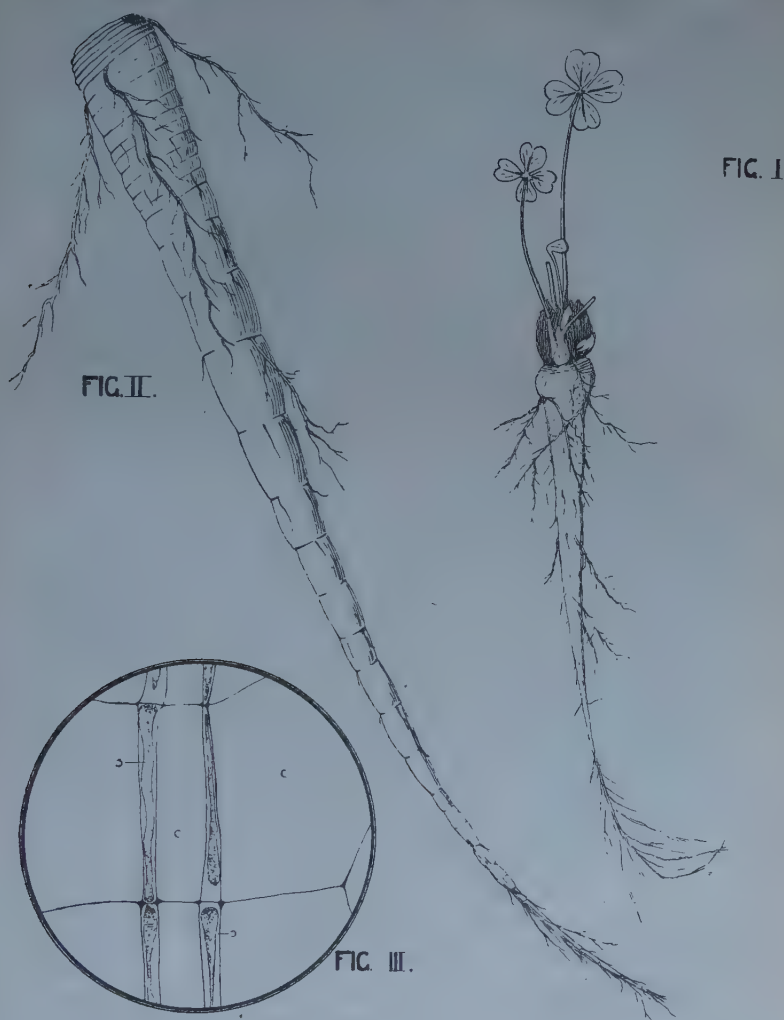
The organs, now known as "pull roots," or "contractile roots," were first studied by Daniel (1) (1891), who, ignoring their contraction, considered them temporary reservoirs of reserve developed under unfavourable nutrition conditions. Rimbach (2) (1898) next studied a large number of species, noted their contractility, and stated that their function was to regulate the depth in the soil of the organ on which they arose. As a general rule these structures are only temporary, but in *Taraxacum* and *Heracleum* they have a double function and are persistent. Rimbach also found that the contraction was not uniform throughout, but was localised in one zone, which, however, was very active, contraction being as great as 70 per cent. in some cases (3).

Oxalis esculenta is a bulbous form which gives rise to a fibrous root system and tetrafoliolate leaves with pinnae of the same shape as the common wood sorrel. When bulbs are planted too shallow, naturally or artificially, they produce, along with the fibrous root system, one or more tap-like roots (fig. 1). These, by contraction, pull the plant down to the optimum depth. Axillary stolons with terminal daughter bulbs are given off, which also give rise to "pull" roots.

These roots (fig. 2) resemble a miniature carrot in shape and measure up to 15 cm. long by 11 mm. broad at the thickest part, which is just below the base. They are white in colour, swollen and succulent, and are horizontally furrowed through their length. These furrows are closest together at the base, where their mean interval is 1 mm. The intervals are greatest—7.5 mm.—in the middle, and gradually decrease towards the tip. It bears freely branching fibrous roots in four longitudinal rows. These are most abundant towards base and tip and differ slightly, these at the tip appearing more adapted for anchorage than those towards the base.

The tegumentary tissues (fig. 4) have suberised walls, except just behind the tip, and are in two zones. At first the cortex assumes the function of an exoderm and shows a

gradual transition from cellulose parenchyma to cork. Near the base, however, a many-layered periderm is laid down.



Oxalis esculenta. FIG. I.—Entire plant, $\times \frac{1}{2}$. FIG. II.—Pull root (nat. size). FIG. III.—L.S. phloem showing sieve tubes, *s*, and ground tissue, *c*, $\times 250$.

The stele is nonmedullated and tetrarch, with an extraordinary development of secondary phloem. No trace of endodermis or pericycle is found. In longitudinal section the xylem

elements show great distortion, which is accounted for by longitudinal compression. The xylem elements are spiral and reticulate tracheids, and a few vasa scattered through a matrix of parenchyma containing a large number of tannin sacs. The primary phloem is succeeded at an early stage by parenchymatous secondary phloem. When a longitudinal section is treated with iodine, long wavy lines are seen, which arise close to the xylem and slope downwards and outwards. These are sieve tubes which appear to be formed by secondary division of the secondary phloem parenchyma (fig. 3). The sieve plates are persistent isolated portions of horizontal walls of the mother cells. They show no trace of callose. This tissue, which occupies nine-tenths of the gross area, is composed of cells rectangular in section, with the longest ones vertical. They have clear contents and a considerable amount of octahedral crystals of calcium oxalate. They are laid down in regular radial rows, being formed by a cambium which divides them from the xylem. The cortex is a layer of seven cells depth. The elements are roughly hexagonal, and, like those of the xylem, appear to have suffered longitudinal compression.

When the root has fulfilled its function it is cast off from the plant by an absciss layer of cork which covers over the scar on the parent bulb. The root by this time is dead, the xylem having been rendered functionless.

From inspection of the tissues it is evident that the secondary phloem is the actual agent in contraction, as it alone shows no distortion after the contraction has taken place. The tegumentary tissues are furrowed, the cortex is crushed, and the xylem so distorted as to be rendered useless. These features are most pronounced at the base, showing maximum contraction to be in this zone.

The energy-producing contraction may be chemical. Before contraction the cells are in a state of maximum turgescence, due to their content of high osmotic value. This osmotic pressure is lowered by chemical interaction, resulting in the formation of such insoluble substances as calcium oxalate. With this reduction of osmotic pressure the cells shrink, and their longest axis being vertical, the greatest shrinkage will be in that direction. The lower portions of the root, however, are securely anchored, and so the bulb is pulled down into the soil.

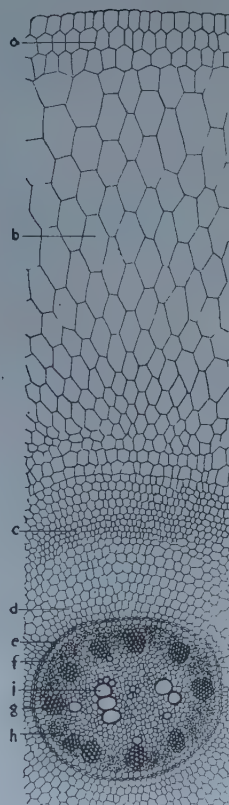
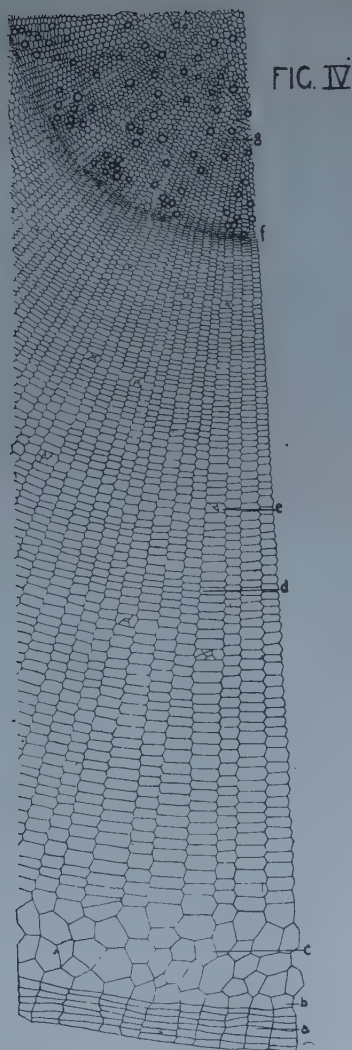


FIG. V

FIG. IV.—Transverse section. Pull root of *O. esculenta*, $\times 25$: *a*, cork; *b*, cork cambium; *c*, cortex; *d*, secondary phloem; *e*, scattered sieve tubes; *f*, position of stelar cambium; *g*, xylem.

FIG. V.—Transverse section. Pull root of crocus, $\times 25$: *a*, exodermis; *b*, outer cortex; *c*, middle cortex; *d*, inner cortex; *e*, endodermis with Casparian strip; *f*, pericycle; *g*, xylem; *h*, phloem; *i*, vasa.

It is interesting to note that here the active agent is the secondary phloem in contrast to forms such as *Crocus*, where the cortex is extraordinarily developed and assumes this function (fig. 5).

The writer wishes to express his indebtedness for facilities and assistance afforded him in the Botanical Department, St. Andrews University, where this work was carried out.

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A NOTE ON RASPBERRY CANKER (*NECTRIA RUBI*,
OSTERWALDER). By N. L. ALCOCK, F.L.S.

(Read 15th October 1925.)

A raspberry plant was received on 17th July 1925 by the author at the Royal Botanic Garden, Edinburgh, from Beaufort Castle, Beauly, Inverness.

The raspberry canes had been turning yellow and dying sporadically, the canes in some cases dying right back at once and in some cases more slowly. When the root of the specimen was carefully washed and the soil cleaned away, numerous perithecia were found on the base of the stems and on the "crown" of the root.

Perithecia.—These are small, red, round bodies, with a mouth or opening that projects a little, making the whole fructification conical in shape. Those examined were about 300–500 μ across, red when immature, turning purple, and almost black when mature. They were clustered in groups in some parts and scattered more or less singly in other places. These fructifications occur below the soil surface, sometimes a few inches below, and are especially frequent in the angle where the cane and root meet, and also in cracks.

Asci.—On cutting a section, the fructification was found to contain a number of asci, and also paraphyses. Both were hyaline, and the asci measured about 100 μ but were rather immature.

Ascospores.—Within the asci the ascospores were in a single row, 8 in number, each mature ascospore divided into 2 cells and slightly constricted in the centre. In the immature the constriction was absent, and the spores were in many cases continuous. They, of course, as well as the asci, were unripe, but their average size was 12.1 $\mu \times 6.6 \mu$, for which measurements I am indebted to Mr. Wallace.

The fungus is said to have a conidial stage of the *Fusarium* type, and a *Fusarium* has been seen on the roots. Cultures are being made both from the perithecia and from the *Fusarium* in order to elucidate the life-history of the fungus. The question of the parasitism of the *Nectria* will be further investigated in the field and by inoculation experiments.

This disease has been recorded and described by Dr. Osterwalder (1), and has been seen and recorded by Dr. Pethybridge and Mr. Lafferty, Dublin, 1916. Sir Frederic Moore of Glasnevin (2) says: "A most unwelcome introduction, as it is so destructive in its action. . . . The disease has been found on parts of the raspberry below ground, in some specimens 9 inches below the surface. . . . The first intimation received that disease is present is the unhealthy appearance of the foliage and subsequent withering and death of the laterals. By this time the underground parts are badly infected."

This disease was described fully by Dr. Pethybridge in 1916, although, so far as I am aware, he has not yet published his description. I am greatly indebted to him for allowing me to use his unpublished account which suggested a search for this parasite. He has now confirmed my diagnosis.

On 9th October 1925 I was at Beaufort Castle with Mr. Greenhowe, Lecturer in Horticulture to the North of Scotland Agricultural College, and we examined the raspberries. Mr. Ames, Assistant in Horticulture, who first observed this disease, was also present. The raspberries had been cleaned up and heavily limed by Mr. Reid, gardener to Lord Lovat. We took a good many specimens, and again perithecia were found. Both red, immature, and purple-black mature perithecia were present, and were found in quantity when the adhering soil had been carefully washed off.

Disease had also been observed by Mr. Greenhowe at Craibstone among certain raspberries, and sporadic dying out and yellowing of canes had been noticed. We collected specimens of these roots, and on these also, when dead or nearly so, the perithecia of *Nectria Rubi* were present, the history of the disease being similar to that at Beaufort Castle.

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- (1) OSTERWALDER: Über eine neue auf kranken Himbeerwurzeln vorkommende *Nectria* und die dazu gehörige *Fusarium*-Generation, Ber. Deut. Bot. Gesell., xxix (1911), p. 611.
- (2) Report of the Consulting Botanist to the Royal Dublin Society, 1916, p. 62.

NOTES ON CANARIAN AND MADEIRAN SEMPERVIVA. By
R. LLOYD PRAEGER, D.Sc.

(Read 15th October 1925.)

Sempervivorum canariensium studium siccis cadaveribus nullomodo promovendum, sed vivis solummodo plantis alendum difficillimumque ob sectiones at auctoribus infelici calamo definitas.—H. CHRIST, Bot. Jahrb., 1888, p. 116.

In preparing an illustrated account of the *Semperviva* (*sensu lato*) at the request of the Royal Horticultural Society of London, the dried material relating to the African section of the group (mainly the Canaries and Madeira) proved ineffective, as without much care these very succulent plants cannot be dried successfully. The material preserved in the leading public herbaria was found to be very incomplete, and much of it of little service. A study based on a large living collection (some 370 plants) obtained from botanic gardens in many parts of Europe was found to be equally unsatisfactory. It became clear that many of these last were garden hybrids of unrecorded and uncertain origin, and it was in many cases as difficult to recognise the pure species as it was to determine the parentage of the remainder. The obvious sequence of work was to begin by collecting the plants in their habitats. With this object, and aided by a generous grant from the Trustees of the Percy Sladen Fund, I spent three months on the Canaries and a week in Madeira in the spring of 1924. All seven islands of the Canarian archipelago were visited, the time spent on each ranging from one to three weeks; on the eastern and western islands my wife and I had the advantage of the company of Dr. Oscar Burchard of Orotava, whose knowledge of the country, the language, and the flora proved very useful.

Our collecting was successful. Out of a known total of about 60 species about 50 were obtained. Of 235 gatherings made for the purposes of study, all but two arrived alive at Glasnevin gardens, thanks largely to the kindness of Captain Pope of the Yeoward liner *Alondra* in placing at my disposal an empty stateroom where the collection was spread out to the air and light:

The fact that six new species are included in the succeeding notes, with three or more to follow, shows that even in this much-collected and attractive group there is plenty of work to be done on the Canaries; several of these new plants are large and conspicuous things, and abundant where they occur. Natural hybrids were supposed to be very rare in the Canarian section of the genus, and indeed, so far as I am aware, only one has been definitely recorded up to the present—*S. Smithii* \times *strepsicladum*, mentioned by Bornmüller as found by R. P. Murray. My collecting shows that hybrids are, on the contrary, not infrequent, often between species of very different appearance. To the presence of natural hybrids is to be attributed, I feel sure, some of the difficulties of the Canarian records of "species," just as it certainly accounts for some of the "species" described from garden material.

The descriptions of new species given below are to some extent preliminary, as the plants have not yet been fully studied in cultivation, and in one instance flowers were not seen—only old inflorescences. As to the new hybrids, flowers were not available in most cases, and descriptions are postponed. But the number of species occurring on Palma, Gomera, and Hierro, where most of the hybrids were obtained, is so small, and the characters of these species so distinctive, that there was generally no room for doubt as to the parentage of the hybrids. Omitting at least one which needs further study, the hybrids found were:

<i>S. hierrense</i> \times <i>canariense</i>	.	.	.	Hierro.
<i>S. hierrense</i> \times <i>valverdense</i>	.	.	.	"
<i>S. valverdense</i> \times <i>canariense</i>	.	.	.	"
<i>S. Castello-Paivae</i> \times <i>canariense</i>	.	.	.	Gomera.
<i>S. Castello-Paivae</i> \times <i>viscatum</i>	.	.	.	"
<i>S. Saundersii</i> \times <i>canariense</i>	.	.	.	"
<i>S. Christii</i> \times " <i>urbicum</i> "	.	.	.	Palma.

I now believe that certain puzzling plants seen on Teneriffe and Gran Canaria during the earlier weeks of our visit were also due to crossing, but at the time I had not fully grasped the limits of variation of the different species (the group is not an easy one) and was not fully alive to the occurrence of hybrids, so they were not studied on the ground. Some were brought back and are now growing.

A subsequent communication will fill the gaps in the present paper, and will deal with a number of overheld plants, such as some species of *Monanthes* and the segregates of the *canariense* group. The range of the Canarian *Semperviva* being still imperfectly worked out, I have set down briefly all the facts of distribution which were noted. The term *Sempervivum* is used to include the genera *Aeonium*, *Aichryson*, and *Greenovia* of Webb and Berthelot. My present view is that these are best treated as distinct, but they are retained under *Sempervivum* for the present, in doing which I follow several recent students of the group.

SEMPERVIVUM, Linn.

Section AEONIUM (W. & B.).

S. arboreum, L.

I have given elsewhere (Journ. of Bot., lxiii (1925), 40) my reasons for believing this to be a Mediterranean species, not a Canarian.

S. balsamiferum, W. & B.

Lanzarote :—The describers say “In rupestribus calidissimis insulae Lancerottae, ubi vulgaris,” but give only one station—Los Quemados, near Mancha Blanca. This is in the centre of the island. There appears to be no subsequent record. I found it on high cliffs in the north in three places :

(1) Under the chapel of Las Niéves, 450 metres (fine old bushes up to 5 feet across).

(2) Sea-cliffs, west-north-west of Haria, 450–600 metres.

(3) Sea-cliffs, Risco de Famara, at the highest part, above the Salinas, about 300 metres.

On Fuerteventura I was shown the plant growing in a grove of *Opuntia* beside a tank in flat cultivated ground half a mile south of Oliva. The station is quite unsatisfactory, and although Dr. Burchard told me that there are other lowland stations in the neighbourhood, I doubt its being native. But it might well occur here in northern Fuerteventura, as does *S. pygmaeum*, which likewise is otherwise confined to Lanzarote.

Lowe (8) states that in Lanzarote the fishermen use this plant to harden and preserve their lines as the Madeira fishermen use *S. glutinosum*. The fact that the species has thus an

economic value may possibly account for its present rarity in Lanzarote, as well as for its occurrence apparently as an introduction in Fuerteventura.

It is not infrequent in European botanic gardens.

S. Burchardii, Praeger, sp. nov.

Suffrutex erectus ramosus glaber 1-2-pedalis. Rami diffusi, circa 6 mm. diametro, cicatricibus linearibus notati, in parte superiore fusci politi, apicem versus foliosi. Folia conferta, non rosulata, obovato-spathulata, 6-10 cm. longa, 2-3 cm. lata, in sectione transversa oblongo-rhomboidea, 5 mm. crassa, apice late cuneata subapiculata, basi subpetiolata petiolo rhomboideo; marginibus ciliata, ciliis brevibus obtusissimis; saturate viridia, lucida, glabra vel apicem versus latere superiore paullo pilosa, medio plus minusve fusco-lineata. Rami floriferi 12-15 cm. longi, foliis oblongo-spathulatis sursus decrescentibus. Inflorescentia subplana vel convexa, minute glanduloso-pilosa, circa 6-10 cm. longa, 10-15 cm. lata, ramis divaricatis dichotomis racemosis circa 6. Pedicelli glanduloso-pilosi circa 7 (5-10) mm. longi. Alabastra ovata. Flores 8-9-meri, 1.5 cm. diametro, ochracei. Calyx 5 mm. longus, dense glanduloso-pilosus, segmentis lanceolatis acutis 3 mm. longis. Petala lanceolata acuta, 8-9 mm. longa, ochracea, medio rubro-lineata, margine parte superiore scabrida. Stamina lutea, epipetala 6.5 episepala 7 mm. longa. Squamae hypogynae minutae, subquadratae, latiores quam longiores, angulis obtusis. Carpella pallide lutea, 8 mm. longa, ovariis brevibus 3 mm. longis, stylis 5 mm. longis.

Species distincta, inter Semperviva affinibus propinquis carens. Foliis saturate viridibus non rosulatis, supra subtusque medium versus incrassatis, floribus ochraceis, petalis medio rubrolineatis distinguenda.

Teneriffe:—"Valle de Masca, in montibus Teno," January 1923, Dr. Oscar Burchard. This station is on the northern coast of Teneriffe, near the western end. Dr. Burchard cannot yet supply any information as to its range or quantity. A plant of very distinct appearance.

S. caespitosum, C. Sm.

Gran Canaria:—Quite local: north-east sector of the central part of the island, abundant. All records refer to this area.

I found it on a bank by the church at Tenteniguada (650 metres); above San Mateo; and from these two places to the summit of the Roque de los Saucillos (1540 metres) abundantly. Webb and Berthelot record it as high as 1650 metres, and it increases in quantity towards its upper limit. A rock-loving plant, forming close, reddish, hairy tufts, resembling those of some of the European *Semperviva*.

S. canariense, L.

Using its name in its older and broader sense, *S. canariense* is one of the most interesting of the genus, on account of its wide range on the Canaries and the different facies which it displays on each of the islands where it occurs. Webb and Berthelot recorded it from Teneriffe, Gran Canaria, and Palma. Webb subsequently (Syn. ined. *ex* Christ (6)) split off the Canaria and Palma plants as *Aeonium virgineum* and *Ae. palmense* respectively, and added Gomera for the restricted *Ae. canariense*. It is locally abundant on Hierro also. *S. canariense sensu lato* thus occurs on all the islands of the group except Lanzarote and Fuerteventura, the flora of which, on account of their smaller elevation and reduced rainfall, differs much from that of the central and western islands. I collected plants from all five islands and have them in cultivation. The Hierro form differs from the type in its very narrow inflorescence, *bright* yellow flowers, and sticky leaves with a strong odour of balsam. Bornmüller (4) considers it is identical with the Palma form, *Ae. palmense*. The Gomera plant is further from type, having smallish very flat rosettes with few offsets (or none) and leaves extremely broad and flat across the apex—in these characters resembling *S. tabulaeforme*. The leaves are scarcely viscid, and have a slight odour, but not of balsam. My present impression is that the Canaria, Palma, Gomera, and Hierro plants must all be separated, at least as subspecies, from the *canariense* of Teneriffe, which is the Linnean plant and is the form figured by the older illustrators.

S. Castello-Paivae (C. Bolle), Christ.

Gomera :—Abundant in Barranco de San Sebastian, from 300 to 850 metres at the Degollada, and thence down to Hermigua and Agulo. Endemic in Gomera. Forms dense very glaucous bushes about a foot in height. Frequent in cultivation.

S. Christii, nomen nov.

(*Aeonium palmense*, Webb ex Christ in Bot. Jahrb. ix (1888), 112. *S. palmense*, Christ, loc. cit., 161; nec *S. palmense*, Christ, loc. cit., 160 (= *Aichryson palmense*, Webb ex C. Bolle in Bonplandia, vii (1859), 243).)

Palma :—Abundant on Palma. Seen in many spots on the eastern side from Mazo to La Galga, mostly in great abundance in the way characteristic of all the segregates of *S. canariense sensu lato*.

Hierro :—The plant of *canariense* type which Bornmüller (4) records as *palmense* was seen in several places about Valverde and in enormous abundance at El Golfo.

If *Aeonium* and *Aichryson* be separated from *Sempervivum*, then the names *Aeonium palmense* and *Aichryson palmense* stand; but both names cannot remain under *Sempervivum*.

S. ciliatum, Willd.

On Teneriffe and Palma, as well as on Gran Canaria, plants were collected which appeared to come under this species, but which were certainly not identical. I suspect hybridism in some cases, and await the development of living material.

S. cruentum, W. & B.

Collected in its classical stations—in Palma from Mazo to (and beyond) Fuencaliente, in Hierro at El Pinar, already (5th May and 15th May respectively) in summer condition, leafless, with small closed ovoid leaf-buds at the tips of the shoots, the flat panicles of golden flowers nearly over. On Palma seen chiefly on the recent lava flows north of Fuencaliente, forming erect twiggy bushes like *Sedum populifolium*, at about 650 metres. Bornmüller (3) got it higher up (1200–1400 m.). Murray (9) says he saw it “in many places” on Palma. On Hierro common at El Pinar, especially in the barranco by the church. No longer on the church (Murray’s station), which has been re-roofed. Not seen below 650 metres here.

S. cuneatum, W. & B.

Teneriffe :—Gathered in its *locus classicus*, the Anaga Mountains. In general appearance much resembles *S. canariense*, but easily known by its entirely glabrous (and in shelter, glaucous) leaves, by the longer cusp at the apex of the leaves, and the taller inflorescence. A very fine plant.

S. decorum (Webb), Christ.

Gomera :—Locally abundant, endemic. A handsome plant ("ex pulcherrimis generis totius," Bolle (1)), much tinged with red. Abundant in the barrancos above San Sebastian, 90–300 metres, but not observed in the valleys about Hermigua.

S. glandulosum, Aiton.

Madeira :—Little Curral and Camara de Lobos. Like Murray (9) I failed to find it in Lowe's Teneriffe station, between Icod de los Vinos and Garachico, seeing only *S. tabulaeforme* there. I doubt very much its being a Canarian plant.

On Madeira in March it was still in its winter condition, the rosettes flat as in *tabulaeforme*, and from 6 inches to $1\frac{1}{2}$ feet across. During the growing season the younger leaves of the first-year plants are erect. Its tall flowering-shoot arises in the early summer of the second year ; it dies after blooming.

S. glutinosum, Aiton.

Madeira :—Abundant on rocks, especially in the lowland zone. Frequent in cultivation in Europe. No variants observed.

S. gomerense, Praeger, sp. nov.

Suffrutex erectus 60–90 (–120) cm. altus, omnino glaber. Rami adscendentes, laxi, subgraciles, nudi nisi apice, infra sublignosi, cortice scabro. Folia spathulata, laxe rosulata, glabra, saturate viridia, circa 6 cm. longa, 3 cm. lata, 5 mm. crassa, apice semicircularia rubro-tincta apiculo parvo depresso, prope basem angustata, breviter petiolata, petiolo rhomboideo ; marginibus tamen in parte media ciliatis, ciliis brevibus obtusis. Rami floriferi circa 30 cm. longi, 12 mm. diametro, in parte inferiore scabri sublignosi. Inflorescentia obtuse et late conica, 15–20 cm. longa, 15–20 cm. lata, ramis circa 20 ; rami inferiores 10–12 cm. longi, apicem versus in ramulos floriferos 4–5 divisi. Alabastra ovato-conica. Flores 8-meri, glaberrimi, viridescenti-albi. Calyx viridis, glaber, dentibus ovato-lanceolatis subacutis partem concretam aequantibus. Petala erecta, apicem versus paullo recurvata, viridescenti-alba, 1 cm. longa, calyce plus duplo longiora. Stamina . . . Carpella . . . Squamae hypogynae quadratae, apice paullo latiores emarginatae.

Species inflorescentiae forma, floribus viridescenti-albis, petalis erectis *S. Castello-Paivae* similis; sed ramis valde longioribus crassioribus, foliis majoribus apice rubro (nec ex toto glaucis), inflorescentia duplo majore glaberrima (nec glanduloso-pubescente), sepalis petalisque staminibusque carpellisue glabris (nec glanduloso-pubescentibus) satis distincta.

Gomera :—Sparingly at the Degollada de San Sebastian, on rocks near the highest point of the pass, on the east side of the path, facing towards San Sebastian, 800 metres elevation. Fl. May.

S. Goochiae, W. & B.

Palma :—About Mazo, Barranco del Rio, Barranco de Santa Lucia, and very abundant in the north from San Juan to La Galga, on rocks, walls, and banks, in the open or under trees. In Barranco de la Galga it hangs down 4 feet on shady rocks. Unlike most species of the genus, it is a successful shade plant, growing on overhanging rocks and under large bramble thickets. O. Kuntze's suggestion (7) to place it under *tortuosum* is simply fantastic, and Bornmüller (3) very properly scouts it.

S. Haworthii, Salm-Dyck.

Teneriffe :—Abundant on the Montaña de Taco, the very perfect little volcano between Los Silos and Buenavista. Confined to a limited area of the coastal region here, and not found elsewhere. Frequent in cultivation.

S. hierrense, R. P.-Murray.

Hierro :—Seen in all the recorded stations—at Valverde, Puerto de Valverde, Tinor, and El Golfo (Murray (9), Bornmüller (3)). A very fine plant, typically unbranched, with leaf rosettes up to 2 feet across and huge inflorescences of pink flowers up to $1\frac{1}{2}$ feet long and 2 feet across. About Valverde it is common—in the barranco below the town, in the crater above it, and in barrancos further south. At the Puerto it is rare. In El Golfo I got it at either end—beyond Sabinosa to the west and at the Pie del Risco and Jinama to the east. Found also at El Pinar and down the barranco there to 450 metres.

S. holochrysum, W. & B.

Seen abundantly, as recorded, on Teneriffe and Hierro, and what I took to be the same thing, also on Palma ; but it was out of flower and I suspend judgment.

S. lancerottense, Praeger, sp. nov.

Suffrutex glaber erectus ramosissimus 1-1½ pedalis. Rami multi divaricati, in parte inferiore nudi subargentei cicatricibus linearibus saturate fuscis notati, apice rosulas foliorum 12-16 cm. diametro ferentes. Folia glabra obovato-spathulata, apice acuta, basi cuneata, sessilia, 7-8 cm. longa, 3.5-4.5 cm. lata, 4-5 mm. crassa, supra concava, subtus convexa, pallide viridia, glaucescentia, anguste rubro-marginata, sparse ciliata, ciliis distantibus brevissimis obtusis suberectis saepe obsoletis (praecipue in parte inferiore). Rami floriferi ramos terminantes, erecti, foliosi. Inflorescentia circa 20 (10-30) cm. longa, 15 (7-25) cm. lata, densa, late convexa, ramis multis strictis alternis composita, rami inferiores circa 15 (8-20) cm. longi, in triente supremo in ramulos floriferos 8-10 identidem ramosi. Alabastra conoidea, 7 mm. longa. Flores 8-meri, ex rubro pallidi, omnes pedicellati, pedicelli 2-3 mm. longi. Calyx glaber, viridis, 3 mm. longus, dentibus deltoideis acutis 1.5-2 mm. longis, 1-1.5 mm. latis. Petala lineari-lanceolata acuta, 6-7 mm. longa, 1 mm. lata, extus rubescentia intus alba, nervo medio lineis rubris notato. Stamina 5 mm. longa, filamentis albis sursum angustatis, antheris luteis. Squamae nectariferae parvae, albae, quadratae, emarginatae. Carpella 5 mm. longa ovariis gracillimis rubescentibus, 2.5 mm. longis, stylis 2.5 mm. longis.

Habitu foliisque *S. percarneo* simile, sed foliis latioribus glaucescenti-viridibus (nec saturate viridibus nec multum rubro-tinctis), ciliis parvis distantibus vel obsoletis (nec confertis nec conspicuis), inflorescentia calyceque glabris (nec puberulis) differt.

Lanzarote :—Locally abundant in the north, 300-600 metres. Roofs in Haria and rocky knoll on its northern outskirts ; high sea-cliffs west and also west-north-west of Haria ; Barranco de Chafariz ; barranco ½ mile north-east of El Valle, etc.

Forming a rather glaucous round bush, 1-1½ feet high. In our climate the red leaf-margin disappears, and the leaf is wholly pale green ; *S. percarneum*, to which it appears most

nearly allied, retains at least a narrow red margin on its leaves.

S. Lindleyi, W. & B.

Teneriffe:—Near Humboldt's Corner; at Santa Urzula; very abundant in barrancos beyond the Cruz de Taganana.

S. Manriqueorum (C. Bolle), Christ.

Gran Canaria:—Seen in many places in the northern half. I am not yet clear as to its relations to *holochrysum* and *arboreum*, but I do not think Kuntze's combining of the three (7) is correct, though Murray's opinion (9) tends in the same direction. *Arboreum* stands quite distinct, both phylogenetically and geographically, but the other two seem closely allied.

S. nobile, Praeger, sp. nov.

Herba amplissima, notabiliter solida. Caulis simplex, erectus vel adscendens, sterilis ad 30 cm. longus, 2.5 cm. crassus, infra sublignosus, nudus, scaber, apice rosulam laxam foliorum ferens. Folia maxima, durissima, obovata, apice semicircularia, basi in petiolum brevem attenuata, ad 30 cm. longa, 12 cm. lata, medio 1 cm. crassa, marginibus 3 mm. crassa, pallide viridia, glabra, viscosa, margine in parte inferiore (rarius etiam in parte superiore) ciliata, ciliis paucis parvis basi latis. Ramus floriferus terminalis, erectus, circa 30 cm. longus. Inflorescentia ex ramulis permultis racemosis composita, superficie subplana, ad 30 cm. longa, 20 cm. lata; ramuli minute glanduloso-pubescentes, in parte superiore racemoso-ramosissimi, ramulis ultimis saepe dichotomis flores multos secundos pedicellatos ferentibus. Pedicelli inferiores 2 mm. longi, superiores brevissimi. Flores 7-meri. Calyx 3 mm. longus, segmentis ovatis acuminatis partem concretam superantibus. Petala . . . Stamina . . . Squamae nectariferae. . . Carpella 4 mm. longa, ovario 2.5 mm. longo, stylo recto 1.5 mm. longo.

Planta insignis, singularis, ab Sempervivis omnibus aliis folio ipso facile distinguenda. Folia enormia, manum hominis longitudine atque latitudine aequantia, crassissima, durissima, gravissima, juniora viscida. Inflorescentia etiam insolita. Flores non visi, fructus solum adest.

Palma :—On hot rocks facing south, about 120 metres elevation, in the two large adjacent barrancos about 6 kilometres north of Santa Cruz ; in each case close to the carretera (carriage-road) a little north of the bridge over the stream-bed.

Easily distinguished by its leaves alone, which in size, thickness, and texture differ widely from those of any other species. The flat-topped inflorescence also is very distinctive, that of most of the larger *Semperviva* being conical or ovoid. A remarkable and striking plant, well adapted to its habitat on very hot rocks, which are shunned by most of the *Sempervivums*. The concomitants of *S. nobile*—*Euphorbia canariensis*, *Kleinia neriifolia*, etc.—show that it is quite a desert type. No flower was obtained, and of about 100 plants seen only one had bloomed in the previous year. The remains of other individuals which had flowered and died were at least several years old, so the plant is evidently slow-growing and long-lived. The large solid leaves are not persistent on the plant, but fallen dried leaves, like tough brown parchment, persist long upon the ground.

S. palmense, Christ. See under *S. Christii*, Praeger.

S. percarneum, R. P. Murray.

Gran Canaria :—Seen in its classical station at Caldera de Bandama ; also on roofs at Tafira, at Cuesta de Silva in profusion, and in a barranco east of that place. Noted also at Valsequillo.

S. Saundersii (C. Bolle), Christ.

Gomera :—Barranco de la Laja, beginning at 600 feet ; still abundant at 2000 feet. A bushy little plant with tortuous stems, already (23rd May) in summer condition, bare of leaves save for the small closed globular buds at the tips of the branches. Confined to Gomera, and on Gomera to this one valley.

S. sedifolium (Webb), Christ.

Teneriffe :—One plant on the north rim of the crater of the Montaña de Taco beyond Los Silos. One of the most distinct of all the Canary *Semperviva*.

S. Smithii, Sims.

Teneriffe :—Several fine old clumps on the edge of the small barranco under the Roques de Guimar, about 1550 metres. A rare and interesting plant, endemic in Teneriffe, long known in cultivation.

S. strepsicladum, W. & B.

Teneriffe :—On both sides of the small barranco under the Roques de Guimar, about 1550 metres.

S. tabulaeforme, Haw.

Teneriffe :—Near Humboldt's Corner, and abundant from Icod to Garachico. In cultivation usually unbranched and dying after flowering, but not so in nature; it frequently makes offsets from the base, or the single crown may divide into two to five crowns. One of the most striking plants of the Canarian flora.

S. undulatum, W. & B.

Gran Canaria :—Frequent on cliffs in the northern glens, 600–1500 metres. Barranco de Culeta, near Tenteniguada; barranco at and above San Mateo, abundant; barrancos north, north-east, and west of Roque de los Saucillos; about Teror; abundant in Barranco de los Tiles above Moya. Fl. April–May. This species is characteristic of the mountain glens of Gran Canaria, growing with its ally *S. Manriqueorum*, from which it is distinguished by its larger size, less-branched habit, darker-green leaves without brown median markings, and very much larger inflorescences, as well as by the shape of the petals, etc. A very fine plant, its massive golden pyramids of bloom only equalled by the greenish-white inflorescences of *S. urbicum* or the pink ones of *S. hierrense*.

S. urbicum, C. Sm.

Common on Teneriffe, but I am not sure at present regarding the Palma records or about plants which I collected there and on Gran Canaria. The Teneriffe plant is variable; about Villa Orotava a fine glaucous form is characteristic, while at Laguna and Anaga the leaves are green.

S. valverdense, Praeger, sp. nov.

Suffrutex erectus laxe ramosus. Caulis 60–90 (ad 120) cm. altus, lignosus, cortice scabrissimo, annulis tumidis 5–10 cm. inter se distantibus notatus. Rami divaricati simplices, ad 45 cm. longi irregulariter 3–5-verticillati, infra nudi, apice rosulam laxam foliorum ferentes, post anthesin emortui.

Folia obovata vel spatulata, 10–12 cm. longa, 5–6 cm. lata, 8 mm. crassa, apice rotundata vel late cuneata, depresso-apiculata, basem versus attenuata, subpetiolata, utrinque minutissime pubescentia, marginibus ciliatis ciliis amplis patentibus, cinereo-viridia, marginibus apiceque saepe rubescentibus, supra plana, subtus medium versus incrassata. Rami floriferi ramos terminantes, foliosi foliis oblongo-lanceolatis minute pubescentibus rubescentibus. Inflorescentia glanduloso-pubescentia, circa 30 cm. alta, 30 cm. lata, late conica apice rotundata; ramuli semel dichotomi ramulis binis floriferis. Pedicelli ad 6–7 mm. longi. Alabastra conica. Flores 7–8-meri. Calyx pubescens, dentibus longe lanceolato-deltoides acutis 4–5 mm. longis, basi 2 mm. latis, partem concretam triplo superantibus. Petala erecta, lanceolata, acuta, 12 mm. longa, albescentia, dorso pubescentia rubescentia albo-marginata. Stamina 9–10 mm. longa, filamentis hirsutis attenuato-deltoides, antheris albescenti-flavis. Squamae nectariferae subsemicirculares, subretusae, albae, 1 mm. latae. Carpella gracilia alba, 9–10 mm. longa stylo ovarium aequante.

Inflorescentiae forma, florum forma coloreque, *S. hierrensi* simile. Sed habitu ramoso perenni, inflorescentiis minoribus lateralibus, floribus majoribus, etc., valde differt. Fl. April–May.

Hierro :—Locally abundant, occurring mainly at low levels. Puerto de Valverde, descending to 15 metres over sea at the quay; very abundant at 90–150 metres in the Barranco de Valverde, ceasing at about 450 metres; in barranco between these places; one plant at 750 metres on edge of Caldera above Valverde; wall at El Pinar, and in the barranco there, increasing downwards, and abundant at 450 metres (the lowest point reached).

On poor ground or in exposure the plant forms a low tuft, but a well-grown specimen has a most characteristic habit. A fine plant in Barranco de Valverde had an erect stem 1.2 metre high and 17 cm. circumference at base, with no less

than ten whorls each of 2 to 5 branches, the whorls 7 to 12 cm. apart, the whole resembling a miniature conifer, which resemblance is increased by the very rough bark, like that of *Pinus sylvestris*. Inflorescences all lateral, the main stem apparently not flowering normally.

In the shape and ciliation of leaves this species much resembles *S. hierrense*, with which it is frequently associated, but there are many marked differences:—

Stem branched and very rough in *valverdense*, unbranched and smooth in *hierrense*; inflorescence lateral and about 30×30 cm. in *valverdense*, terminal and 45×45 cm. in *hierrense*; leaves finely downy and pale, often yellowish, in *valverdense*, glabrous and purple-glaucous in *hierrense*; branches of inflorescence simply dichotomous in *valverdense*, bearing 3–5 dichotomous branchlets in *hierrense*. The flowers of *valverdense* are half as long again as those of *hierrense*, and the scales are subsemicircular and slightly retuse instead of quadrate and emarginate.

S. virgineum, Christ.

Gran Canaria:—Enormously abundant in Barranco de la Virgen and Barranco de los Tilos, and in the Cuesta de Silva down to sea-level, whence it continues along the coastal cliffs to Bañaderos de Arucas, and inland from Firgas to a couple of miles east of Arucas. It has thus a wider range than has been attributed to it.

S. viscatum (Webb), Christ.

Gomera:—Barranco de San Sebastian, beginning at 100 metres, and Barranco de la Laja abundant up to the Degollada (850 metres), and thence down to Hermigua and Agulo. Young plants are glandular-hairy, recalling the leaves of *Goochia*. Endemic in Gomera.

Section AICHRYSON (W. & B.).

S. annuum, C. Sm.

Like *S. punctatum*, occurs on all but the two eastern islands—on Gran Canaria, Teneriffe, Gomera, Hierro, and Palma, in shady and half-shady places. In the Gomera woods it is a

successful epiphyte, flourishing on the mossy trunks of tall trees up to 30 feet above the ground.

C. Bolle includes it in his flora of Fuerteventura and Lanzarote (2), but gives no locality: its occurrence on those very dry islands seems unlikely.

S. Bethencourtianum (Webb), Christ. --

Fuerteventura:—"In catena montium Handiae" is the only information which Bolle (1) vouchsafes as to the only known station for this plant, which apparently has not been gathered subsequently save by Bourgeau (Pl. Canar. 737). Handia presents a 10-mile range of lofty cliffs rising in Pico de la Zarza to 850 metres, and mostly very difficult to work. I found the plant on rocks a little north of the summit of the pass leading from Gran Valle to Cofete, at about 450 metres. It is much like an overgrown *A. pygmaeum*, but seems quite distinct.

S. divaricatum (Aiton) Lowe, *a. polita*, Lowe.

Madeira:—Little Curral above Funchal.

S. pachycaulon (C. Bolle), Christ.

Fuerteventura:—Pico de la Zarza, 850 metres, growing in sheets of damp moss on the cliffs at the summit. Stout plants up to 2 feet high, sometimes strongly branched. Beginning to flower in mid-March. Apparently not collected since Bolle's original discovery of it in 1854 (1).

Webb apparently proposed to unite this with *immaculatum*, Webb (see Bot. Jahrb., ix (1888), 108). My plants of *pachycaulon* are still immature, and I cannot express an opinion. It comes very near *punctatum*.

S. palmense (Webb), Christ in Bot. Jahrb., ix (1888), 160 (*nec S. palmense*, Christ, *loc. cit.*, 161=*S. Christii*, Praeger).

Palma:—Along the tarjeda (water conduit) in the Barranco de la Galga, where I had gone to look for *A. parviflorum*, another of Bolle's one-station species. Bolle's station for *A. palmense* lies several miles further north. Distinguished from *A. dichotomum*, which grew with it, by its more hairy, clammy leaves, very divaricate branches longer than the main stem, and larger, scattered, paler flowers.

S. pulvinatum, nov. comb.

Fuerteventura :—Dr. Burchard took me to one of the original stations of his *Aichryson pulvinatum*—hills south of Oliva. I cannot distinguish the plant in any way from *S. pygmaeum* of Lanzarote.

S. pygmaeum, C. Sm.

Lanzarote :—Common on rocks and cliffs throughout the northern portion of the island from Risco de Famara to Las Niéves, and in a small crater $\frac{3}{4}$ mile west of San Bartolome in the centre of the island.

Fuerteventura :—Common on the hills south of Oliva (*A. pulvinatum*, Burchard).

S. villosum, Aiton.

The type, which is confined to Madeira, was collected in a ravine north-east of Funchal.

β *subvillosum* (Lowe), Bornm.

Pitard and Proust (10) do not give separately the distribution of this and the succeeding variety. *Subvillosum* was seen often in abundance on Gran Canaria, Teneriffe, Gomera, Hierro, and Palma. It is an inhabitant of dry sunny places—rocks, walls, and roofs; a hairy, bushy little plant, mostly only a few inches high. It extends to 1540 metres on Gran Canaria.

A subglabrous form occurred on dry rocks east of Laguna.

γ *punctatum* (C. Sm.), Bornm.

Seen on Teneriffe, Hierro, and Palma—possibly elsewhere, but not noted. A plant of damp shady places, with smooth, shining, dark-green leaves, and stems from 3 inches to 3 feet in length, the large state occurring on dripping banks or on the edge of running water.

Section GREENOVIA (Webb).

S. Aizoon, Christ.

Teneriffe :—Gathered at Roques de Guimar, about 1650 metres, growing along with *S. rupifragum*, from which it was not distinguished at the time; but under a lens its fine coating of dense hairs is most distinctive. Since my return home Dr.

Burchard has sent it from near Igueste, whence it was recorded by C. Bolle (1).

S. aureum, C. Sm.

What I took to be this common species was seen on all the islands except the two eastern ones; but the segregates *polypharmica*, *diplocycla*, and *ferrea* were not recognised on the ground, and some plants may be referable to these. Essentially an upland species, seldom found at low elevations (180 metres, Barranco de San Sebastian, Gomera); often enormously abundant on the mountain cliffs; to 1650 metres on Roque de los Saucillos, Gran Canaria.

S. gracile (C. Bolle), Christ.

Teneriffe:—Dr. Burchard guided me to the station for this species in the Barranco Tajodio, near Santa Cruz. The plant extends here over a quite limited area, at 275 metres elevation on the west side of the stream, half a mile above the reservoir, just below where the barranco bends eastward. The habitat is peculiar; it grows in a thin skin of moss on the face of rubbly red rocks, without soil, where it forms close clumps up to a foot across. Just out of flower at the time of my visit (17th April). The plant was already in its summer condition, and the rosettes were like pink globular eggs, from the size of a marble down.

The only other published station is the Barranco Martianez, near Orotava, given by Buch (5) and alone mentioned by Pitard and Proust. Both Dr. Perez and Dr. Burchard have sought it there frequently without success; but Dr. Burchard has discovered a new station for it in western Teneriffe—between Buenavista and Teno, about 500 metres elevation.

S. rupifraga (Webb), Christ.

Teneriffe:—Roques de Guimar, about 1650 metres. Rather widely spread in this, its only known station, on the cliffs and in the barranco. Forms close cushions of green rosettes one-third the size of those of *aureum*, and much more numerous and uniform in size than in that species. Just commencing to flower on 1st May.

MONANTHES, Haworth.*M. anagensis*, Praeger, sp. nov.

Suffruticulus erectus, glaber, valde ramosus, ad 15 cm. altus. Rami cinerei tortuosi nudi apicibus exceptis. Folia alterna, non rosulata, sessilia, glabra, lineari-elliptica (vel in cultu linearia), obtusiuscula, subteretia, supra subplana canaliculata, 10–13 mm. longa (in cultu ad 25 mm. longa), 4 mm. lata, 3 mm. crassa, viridia, rubescentia vel purpurea. Inflorescentia pseudo-terminalis 2–6-flora, pedicellis glabris filiformibus ad 25 mm. longis. Alabastra late ovoidea. Flores plani 7-meri, 1 cm. lati, viridescenti-lutei. Calyx glaber, segmentis deltoideis subacutis, partem concretam aequantibus. Petala deltoideo-lanceolata, acuta, 4 mm. longa, viridescenti-lutea, nervo rubescente. Stamina petala fere aequantia filamentis rubescentibus, antheris flavis. Squamae nectariferae 1 mm. longae, 1.5 mm. latae, in parte inferiore angustae, in parte superiore in lobos binos subcirculares scabros pallide virides expansae. Carpella brevia, 2.5 longa, stylis primo erectis conniventibus, postea divergentibus.

Habitu fruticoso erecto 10–15 cm. alto, ramis tortuosis, foliis longis angustis, ab congeneribus suis longe differt. Fl. May–June.

Teneriffe:—Abundant along the Anaga watershed, 600–900 metres, on rocks.

It is surprising that this plant has escaped observation, as it grows in profusion at many places along the well-known road which follows the ridge of Anaga from Hermita Carmen to the Cruz de Taganana, mixed with *M. laxiflora* (*agriostaphis*), from which it is immediately distinguished by its shrubby growth and narrow light-green or reddish leaves. In growth and shape of leaf it so closely resembles *Sedum fusiforme* of Madeira that at first I thought I had found that species on the Canaries, but subsequently flower was seen which belonged quite typically to *Monanthes*. It is abundant up to 2 kilometres beyond the Cruz de Taganana, and no doubt continues further eastward.

M. brachycaulon, Lowe.

Pitard (10) divides this into three varieties—*Teneriffae*, *Canariae*, and *Gomerae*. I got it abundantly on Teneriffe and Gran Canaria, but postpone discussion of its varieties.

M. laxiflora, Bornm. (*Petrophytes agriostaphis*, W. & B.).

On record only from Teneriffe and Gomera. I gathered it in a number of stations on both islands, and what seemed the same thing on Gran Canaria, Fuerteventura, and Lanzarote. Two plants which come very near it are recorded—*P. tilophila* from Gran Canaria, and *P. microbotrys* from Fuerteventura. I await the development of my living material for definite determination.

M. muralis (Webb), Christ.

Hierro:—In the classic localities of Valverde (where it is abundant on walls, houses, and rocks) and El Golfo; also at Mocanal and El Pinar.

M. polyphylla, Haworth.

In a number of stations on Teneriffe and Gomera.

The species of *Monanthes* are somewhat puzzling. I believe I obtained several species in addition to those given above, but await the development of cultivated material.

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TRANSACTIONS
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SESSION XC

NOTES ON FIFE AND KINROSS ROSES.

By J. R. MATTHEWS, M.A.

(Read 19th November 1925.)

Rosa? “seems to have touches of *dumalis*, *subcristata*, and *urbica*, and is therefore unnameable.” Such is J. G. Baker’s comment on a specimen, collected from Orrock Hill, Fife, 1874, now preserved in the herbarium, Royal Botanic Garden, Edinburgh. It is a fair expression of the difficulty encountered by an experienced rhodologist fifty years ago. The lapse of half a century has not made the difficulty any less. Rather has it increased, for while the earlier workers were content with a relatively small number of species and a moderate number of varieties, the student of to-day is confronted, if he takes the recent (eleventh) edition of the London Catalogue as his guide, with the names of sixteen species, one hundred and sixty-eight varieties, and twenty-six hybrids.

That most indefatigable worker at the genus, Col. A. H. Wolley-Dod, in his account of the Roses of Britain (1924), writes: “That the naming of Roses does present real difficulties is evidenced by the fact that Crépin, one of the best authorities, in his later days seldom gave a precise varietal name to a specimen, but only gave his opinion as to the species or group to which it belonged. This, of course, is of little help

to the student, who requires something more definite." In the same work, he restates a view he has expressed more than once, that many of the descriptions given by authors are obviously those of individual bushes.

Difficulties notwithstanding, I have ventured in the following pages to set down names for a considerable number of specimens which have been collected during the past five years in various parts of Fife and Kinross. The list makes no claim to be exhaustive, since only a small portion of the area has been explored, but it has been made as complete as possible by means of supplementary notes on certain Fifeshire specimens in the Botanic Garden herbarium. Many of these are gatherings made by F. M. Webb in 1876, mainly from Burntisland district. The herbarium contains no recent gatherings, and the publication of these notes may fill a gap in our knowledge of the local distribution of roses. It is at least remarkable that among the hundreds of records in Wolley-Dod's Revised Arrangement of British Roses, 1920, giving the comital distribution of the genus, there is only one which relates to vice-county 85 Fife and Kinross.

The earliest record of which I have knowledge is to be found in Lightfoot's *Flora Scotica* (1777), where *Rosa villosa*, Linn. is reported as occurring "upon the coast of Fife." Greville in *Flora Edinensis* (1824) mentions *R. spinosissima*, Linn., growing on hills above North Queensferry, and Woodforde, in his *Catalogue of Plants growing in the Neighbourhood of Edinburgh* (1824), gives the same locality for this species. Balfour and Sadler (1863) record five species from the county: *R. spinosissima*, Linn., *R. villosa*, Linn., *R. tomentosa*, Sm., *R. rubiginosa*, Linn., and *R. canina*, Linn. Sonntag (1894) adds *R. scabriuscula*, Winch, from Burntisland, and *R. dumetorum*, Thuill., and *R. Watsoni*, Baker, both from Dollar. In the list which follows, the names are given of eleven aggregate species and about forty varieties.

The field observations have been made chiefly along the coast from Inverkeithing to Kirkcaldy and in Kinross-shire, and apart from the recognition of a considerable number of segregates in this small area, there are certain features in the distribution of some members of the genus to which attention may be directed. It is well known that members of the *canina-dumetorum* series are found most abundantly in the

southern counties of Britain. There they are common and widely distributed. In the north of England and in the south and midlands of Scotland these two species are still frequent, but they mingle with their boreal derivatives *R. glauca* and *R. coriifolia*; while, in the extreme north of Scotland, *R. canina* and *R. dumetorum* are practically if not entirely absent, their place being taken by the *glauca-coriifolia* series. This feature in the horizontal distribution of the two series, the replacement of the southern *canina* and *dumetorum* by *glauca* and *coriifolia* in the north, is repeated within the Fife and Kinross area, where, however, the determining factor seems to be altitude. The vertical distribution of the species within the limits of this single vice-county reflects, roughly, their horizontal range within Britain as a whole. Along the south coast of Fife the dominant species of the rose flora are *R. canina* and *R. dumetorum*. Passing northwards to the borders of Kinross-shire, we find *R. glauca* and *R. coriifolia* becoming more abundant, while on the south slopes of the Ochil Hills these are the two prevailing species. In point of fact, of 122 bushes examined in the district around Milnathort, 119 were referable to *R. glauca* or *R. coriifolia*, only three being members of the *canina-dumetorum* series. Regarding the distribution of other species of the genus, precise data are not yet available, but *R. mollis* and *R. omissa* seem to favour the higher ground, although they occur also in situations almost at sea-level. *R. spinosissima*, essentially a coastal species, is not entirely absent inland, occurring occasionally on relatively dry, shallow soils.

In the list which follows, the names are those of the London Catalogue, eleventh edition. Many of the so-called varieties are mere forms, and for an opinion regarding the status of our native roses, reference should be made to *The Roses of Britain*, by Col. Wolley-Dod.

R. ARVENSIS, Huds. var. *ovata* (Lej.).—Between Burntisland and Aberdour. A specimen in Herb. R.B.G. Edin. collected by Webb in 1876, "about $1\frac{1}{4}$ – $1\frac{1}{2}$ m. beyond (N.N.W.) of Aberdour," is also var. *ovata*. Probably an introduction but now thoroughly established.

R. SPINOSISSIMA, Linn.—Wolley-Dod proposes the varietal name *typica* for those plants with glandular-hispid peduncles, retaining the name *pimpinellifolia* for forms with smooth

peduncles. *Var. typica* occurs plentifully near Tillyrie, Milnathort. Specimens from "near Burntisland, 1835," and from "Seashore near Dysart, 1854," in Herb. R.B.G. Edin., belong to this variety. Another example labelled "*Rosa spinosissima* β *Rosa Ciphiana*, Sibbald, Hills above North Queensferry where *Oxytropis uralensis* grows, June 1830," is of historic interest. Sibbald's plant was simply a pink-flowered form of *R. spinosissima* which grew in his Ciphian Garden. Pink to rose-coloured forms of the species have been distinguished as *var. rosea*, Koch, but they do not deserve varietal rank.

R. CANINA, Linn.—As an aggregate this is common. The following segregates have been noted: *Var. lutetiana*, Lém., at Inverkeithing, Burntisland, Kinghorn, and Blairadam; *var. sphaerica* (Gren.), same localities, especially abundant along the coast; *var. senticosa*, Baker, high road between Burntisland and Kinghorn; *var. mucronulata* (Déségl.), Burntisland; *var. insignis* (Déségl. et Rip.), Blairadam and Gateside; *var. dumalis* (Bechst.), frequent in the vicinity of Burntisland and Kinghorn; *var. adscita* (Déségl.), Burntisland; *var. verticillacantha*, Baker, near Blairadam, very rare.

R. DUMETORUM, Thuill.—For the type of this species Wolley-Dod proposes the name *var. typica*. I have not gathered any specimen which matches the description, but an example collected by F. M. Webb from Burntisland, 1876, preserved in Herb. R.B.G. Edin., and labelled *R. canina*, Linn., *var. dumetorum*, Thuill., seems fairly typical. Crépin suggested *R. obtusifolia*, Désv., for Webb's specimen, but it is not that, *R. obtusifolia* being a variety of *R. tomentella*, Lem., a species not known to occur in Scotland. Webb's determination is correct. More frequent than the type is *var. semiglabra* (Rip.), noted from Inverkeithing, Burntisland, Milnathort, and Mawcarse; *var. jactata* (Déségl.), near Inverkeithing; *var. ramealis* (Pug.), Blairadam. As an aggregate, *R. dumetorum* is not so abundant as *R. canina*.

R. GLAUCA, Vill.—Very common in the north of the vice-county. *Var. Reuteri* (God.), between Burntisland and Kinghorn and near Milnathort; *var. transiens* (Gren.), Blairadam and Milnathort; *var. subcristata* (Baker), by far the commonest variety of the species, occurring near Burntisland and Kinghorn and plentifully in Kinross-shire. There are

four specimens in Herb. R.B.G. Edin., collected by Webb near Burntisland in 1876, all of which belong to this variety, although one of them approaches var. *myriodonta* (Chr.), of which I have seen one good example near Milnathort. Var. *adenophora* (Gren.), Blairadam, Milnathort, and Crook of Devon, also near Newburgh, ex Herb. W. Barclay, 1918; var. *stephanocarpa* (Déségl. et Rip.), not infrequent in the same localities as the last. Although in the original description of *R. glauca* the leaflets are described as glaucous, they are not invariably so.

R. CORIIFOLIA, Fries.—Generally distributed on the higher ground, but not so abundant as *R. glauca*. The type, var. *typica*, Chr., occurs near Milnathort and near Crook of Devon; var. *frutetorum*, Chr., at Milnathort; var. *Watsoni* (Baker), several places in the vicinity of Milnathort; var. *subhispidula*, W.-Dod, frequent, Blairadam, Milnathort, and Crook of Devon; var. *Bakeri* (Déségl.), several bushes near Milnathort and at Mawcarse; var. *setigera*, W.-Dod, near Milnathort; var. *Lintoni*, Scheutz, occasional near Milnathort, also near Newburgh, ex Herb. W. Barclay, 1918; var. *subcoriifolia* (Barclay), frequent, especially near Crook of Devon; var. *incana* (Borr.) rare, Crook of Devon and Milnathort; vars. *subcollina*, Chr., *caesia* (Sm.), and *obovata* (Baker), noted as rare near Milnathort. One of Webb's specimens in Herb. R.B.G. Edin., collected in 1876, "Roadside east of Balmuto, Fife," and labelled *R. canina*, var. *marginata*, Wallr., is *R. coriifolia*, var. *Watsoni* (Baker).

R. POMIFERA, Herrm.—There is little doubt that *R. villosa*, Linn., covered those forms for which the names *R. mollis*, Sm., and *R. pomifera*, Herrm., are now used. Lightfoot, as already mentioned, refers to *R. villosa* as occurring "upon the coast of Fife," and it is of interest to note that in Herb. R.B.G. Edin. there is a sheet ex Herb. Col. James Brodie of Brodie, labelled *R. villosa*, Linn., but neither date nor locality is given, although Lightfoot's locality is quoted. The specimen is undoubtedly *R. pomifera*, Herrm., a rare rose in Britain and doubtfully native in the few vice-counties from which it has been recorded. Typical *R. pomifera* does occur "upon the coast of Fife." I have gathered it near St. Davids, and Mr. W. Edgar Evans informs me that he has a specimen in his herbarium from the same locality.

R. mollis, Sm.—Common, especially in Kinross-shire, but occurs near sea-level at Burntisland. There is no difficulty in recognising the species as an aggregate, but it exhibits much variation. The segregation into four varieties—*typica*, W.-Dod, *glandulosa*, W.-Dod, *caerulea*, Baker, and *pseudo-rubiginosa* (Lej.)—is unsatisfactory. All four occur in the vice-county, but I am unable to give distributional details. The type is described as having deep-red petals. They are often white. There are several of Webb's specimens in Herb. R.B.G. Edin., the majority from Burntisland and one from Ladybank. A Burntisland specimen, collected 2nd September 1876, is described by Crépin as approaching *R. pomifera*, Herrm., but in my opinion it shows little resemblance to the true *pomifera*. A specimen of *R. mollis* collected near Newburgh, ex Herb. W. Barclay, 1918, could equally well be referred to var. *glandulosa* or *caerulea*.

R. omissa, Déségl.—This is even more difficult to segregate than *R. mollis*. As an aggregate it is common, especially on the higher ground, but it occurs occasionally on sand-banks near sea-level. Var. *typica*, Kell., near Inverkeithing, Burntisland, Milnathort, and Crook of Devon; var. *resinosoides* (Crép.), frequent in the districts just mentioned, and at Newburgh, ex Herb. W. Barclay; var. *Sherardi*, Davies, near Milnathort; var. *submollis* (Ley), near Milnathort; var. *uncinata* (Lees), at Inverkeithing; var. *suberecta* (Ley), frequent, Burntisland and Milnathort; var. *cinerascens* (Dum.), very rare, near Blairadam.

R. tomentosa, Sm.—This is not so common as *R. omissa*, with which it is easily confused. A specimen of Webb's collecting, from Ladybank, July 1876, in Herb. R.B.G. Edin., is referred correctly to this species, but most of his gatherings placed under *tomentosa* should be transferred to *R. omissa*. Var. *eglandulosa*, W.-Dod, near Milnathort; var. *pseudocuspidata* (Crép.), near Burntisland; var. *scabriuscula*, Baker, near Milnathort.

R. rubiginosa, Linn.—Frequent in the hedges about Milnathort, also near Inverkeithing, Burntisland, and Blairadam. Var. *apicorum* (Rip.), near Newburgh, ex Herb. W. Barclay, 1918; var. *echinocarpa*, Gren., near Inverkeithing.

There is still much ground to be covered before the list of

Fife and Kinross roses can be made complete, yet the foregoing notes may serve to direct attention to the existence of a considerable number of recognisable forms within the aggregate species. The genus is remarkable for its polymorphy, and affords ample material for the study of variation. May I express the hope that our field botanists will assist in the elucidation of our local forms ?

A NOTE ON THE FLORA OF SALISBURY CRAGS.

By J. R. MATTHEWS, M.A.

(Read 21st January 1926.)

In a paper which was communicated to this Society last session and which appeared in the Society's Transactions (vol. xxix, p. 119), Mr Wallace presented a comparative account of the flora of Salisbury Crag based upon records of different dates, which he had drawn from various lists, including one he himself had prepared during 1924. The general conclusion was reached that the past century had witnessed a considerable change in the Salisbury Crag flora, involving a marked diminution in the number of species.

It may be of interest to local botanists to supplement Mr. Wallace's contribution to our knowledge of the history of this particular flora by reference to a list of Eighteenth-Century Records of British Plants—a record of earlier date than any mentioned in his paper. This list was communicated to the Annals of Scottish Natural History for July and October 1900, and January 1901, by Professor Isaac Bayley Balfour, and is a transcription of a manuscript which had belonged to Dr. John Hope, who was Regius Keeper of the Royal Botanic Garden from 1760 until 1786. The first page of the manuscript bears the title, "List of Plants growing in the Neighbourhood of Edinburgh, collected in flower, 1765, as a sketch of the *Calendarium Florae* of Edinburgh." The major portion of the Calendar, which is in two parts, gives numerous citations of localities in the vicinity of Edinburgh, and not an inconsiderable number relates to Salisbury Crag.

I am indebted to Mr. Johnstone for drawing my attention to a reprint of this Calendar in Notes, R.B.G. Edin., No. XVIII, 1907, and in the same publication there is preserved the content of another manuscript of Dr. Hope's entitled, "A Catalogue of British Plants in Dr. Hope's Hortus Siccus, 1768, arranged in the same order as in the *Flora Anglica* Huds. Ed. 1." This catalogue, a long one, contains many references to plant localities near Edinburgh, and Salisbury Crag as a locality is cited definitely for a small number of species.

We have, therefore, two lists of considerable historic interest, which pertain, at least in part, to our local flora at a period

dating back about one hundred and sixty years. In the first list (1765) forty-seven species are given from Salisbury Crags ; in the second (1768), this locality is cited for nineteen species, but eleven of these appear in the list of 1765. Thus, the two catalogues together provide the names of fifty-five plants definitely recorded from this station in the second half of the eighteenth century. I give the list here in a form which makes it available for comparison with those in Mr. Wallace's paper, retaining, however, the original spelling and nomenclature, giving synonyms only where they seem desirable. Although names of authorities are not given in either of the manuscripts, it has generally been possible to indicate the species meant in terms of our present nomenclature. The letters G, W, c, B, S, a, placed after the name of a species, are employed in the same sense as in Mr. Wallace's paper.

LIST OF PLANTS RECORDED FROM SALISBURY CRAGS
IN THE EIGHTEENTH CENTURY.

Turritis hirsuta W, c.
(= *Arabis hirsuta*)
Cardamine petrea ?
C. hirsuta
Erysimum alliaria W, c.
Draba verna W, S.
Cistus helianthemum S, a.
Viola canina c, S, a.
Polygala vulgaris W.
Lychnis viscaria B.
Stellaria Holostea W, c.
Linum catharticum
Geranium sanguineum W, S.
G. robertianum W, c, a.
Oxalis acetocella
Euonymus europaeus W, c, S.
Ononis arvensis S.
O. spinosa
Anthyllus vulneraria S.
Vicia sylvatica G, W, c, S.
V. sepium W, c, S.
Ervum soloniense S.
(= *Vicia lathyroides*)
Rubus Idaeus W, c.
Potentilla verna
Tormentilla reptans
Crataegus aria
Sedum acre W, c, a.
Ribes grosularia
Pimpinella saxifraga G, W, S, a.

Hedera helix S, a.
Sambucus nigra a.
Lonicera periclimenum
Asperula odorata G, W, c.
Sherardia arvensis G, W.
Valeriana officinalis G, W, c.
V. locusta W.
(= *Valerianellae* spp. variae)
Senecio viscosus G, W, B, a.
Hieracium pilosella W, c, a.
H. auricola
H. murorum G, W, c, a.
Primula veris W.
Hyoscyamus niger G, W, S.
Scrophularia nodosa
Salvia verbenaca G, W, c, S.
Thymus serpyllum a.
Clinopodium vulgare G, W.
Plantago lanceolata a.
Allium vineale G, W, c, S, B.
Aira cariophylla G, W, S, a.
A. cristata G, W, c, S, a.
(= *Koeleria cristata*)
Avena fatua
A. pubescens W.
A. flavescens G, W, c, a.
Briza media a.
Poa rigida G, W.
Pteris aquilina

Excluding the Bracken, the names of twelve species appear in the above eighteenth-century records which are not mentioned in any of the lists referred to by Wallace. *Cardamine petrea* (= *Arabis petraea*) is almost certainly an error, and is queried in the original manuscript by Dr. Hope. The remaining records are distributed as follows :—

G=Greville, 1824	15
W=Woodforde, 1824	30
c=Collection, 1833-34	17
B=J. Hutton Balfour, 1850	3
S=Balfour and Sadler, 1871	17
a=Wallace, 1924	16

The more conspicuous changes in the flora during the nineteenth century, and the probable causes of these, were discussed by Wallace, and into these matters I need not here enter. An examination of the eighteenth-century records now presented points to a flora composed mainly of rupestral or pascual xerophytes, such as might be expected on an area like Salisbury Crags. Nevertheless, a few species must be recognised as more typically sylvestral or species of forest borderland, suggesting moister conditions than now prevail, and, possibly, the former existence of woodland at no great distance from the Crags. Reference to the historical record is in accordance with the suggestion. Arnot, in his *History of Edinburgh, 1779*, writes: "The environs of the [Holyrood] palace afford an asylum for insolvent debtors. Adjoining to it, there is an extensive park, first enclosed by James V., all of which is a sanctuary. This is a very singular piece of ground to be in the near neighbourhood of a populous city. It is little else than an assemblage of hills, rocks, precipices, morasses, and lakes. In the memory of people not long since dead, the level strip, at the foot of the hill, which, from the Duke of York's having delighted to walk in it, bears the name of *the Duke's Walk*, was covered with tall oaks.¹ But now, there is hardly a single tree in its whole boundaries. Indeed, it is extremely doubtful, if, except at the bottom, there were ever any trees on these hills, the height of the ground, and barrenness of the soil, being very unfavourable for their growth." In early

¹ i.e. south-east of the palace.

days, too, extensive woodland existed in close proximity to the old town of Edinburgh, if not in the immediate vicinity of the Crag. The early mediæval orchard attached to the Castle "extended on the south-east, from the Grassmarket and King's Stables Road to the neighbourhood of Liberton, on the south, to the Burgh Muir, and on the west, to the borders of the King's farm, or 'Dal-ry.' . . . On the north side of the Castle the King's gardener evidently followed the prevailing fashion of the twelfth century in planting trees and shrubs about the base of the Rock, and the evidence of hunting in the forest of Drumselch is testimony to the same meticulous attention to the practices of Royal Houses elsewhere, in having the hunting grounds on the north side of the Castle."¹

There is no need to dwell on the altered conditions. Clearly, the major changes in the flora of Salisbury Crag must be attributed to the manifold activities of man.

¹ See *The Gardens of the Castle*, by C. A. Malcolm, in the *Book of the Old Edinburgh Club*, vol. xiv, 1925.

WARDASTER: A NEW GENUS OF THE COMPOSITAE FROM THE
MARCHES OF YUNNAN-SZECHUAN. By Professor J.
SMALL, D.Sc.

(Read 21st January 1926.)

Wardaster, J. Small. Genus nov. Compositarum.

Genus *Asteroidearum*; prope *Asterem* allocatum; habitu, receptaculo alveolato, antheris mucronatis ad *Celmisiam* propinquat, sed ab genere hoc involucri phyllis, pappi setis parum inaequalibus, rami stylaris appendicibus brevioribus et foliorum indumento lanuginoso haud argenteo-sericeo differt; habitu, phyllis involucri pauci-seriatis et pappi setis parum inaequalibus ad *Asterem* § *Alpigeniam* accedit, sed ab hoc genere receptaculo alveolato et antheris mucronatis divergit.

Herba perennis; caules solitarii vel bini, subscaposi. Folia radicalia congesta; folia caulina pauca.

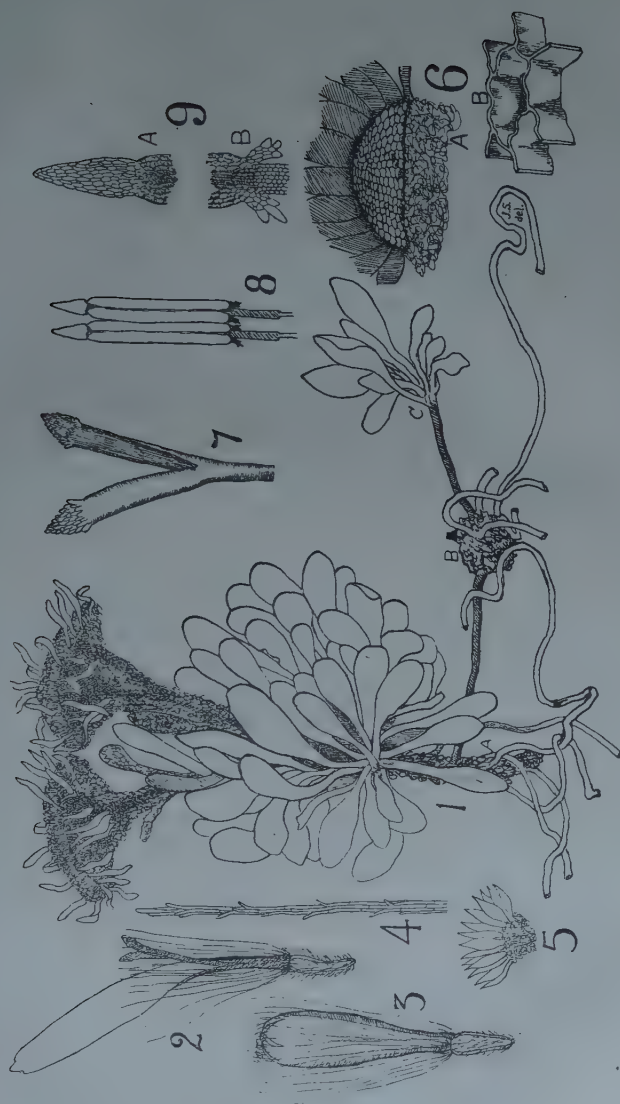
Capitula solitaria, heterogama, radiata. Involucrum late campanulatum; involucri phylla 3-seriata, imbricata, parum inaequalia, circa 10 mm. longa. Receptaculum convexum, alveolatum. Flores ligulati ♀, circa 20-30, violacei; ligulae circa 15 mm. longae, integrae vel minute 3-dentatae; rami stylares latiusculi, appendicibus apicalibus lanceolatis papillois; achaenia 2.5-3.0 mm. longa, compressa, 2-costata, villosula; pappi setae numerosae, pallido-fuscae, parum inaequales, scabridae. Flores disci ♂, numerosae, campanulatae, 7 mm. longae, flavae; antherae basi brevissime 2-mucronatae; rami stylares achaeniaque illis florum ligulatorum similia.

Genus monotypicum chinense provinciae szechuanensis prope fines yunnanenses incola.

Wardaster lanuginosus, J. Small. Spec. nov.

Herba stolonifera; pedunculi erecti herbacei, leviter lanuginosi. Folia radicalia integerrima, petiolata, spatulata, utrinque dense lanuginosa; folia caulina angustiora, lanuginosa, caduca. Involucri phylla lanceolata vel lineari-oblonga, acuta, pluri-nervosa, extra lanuginosa, intus glabra.

“West China: Glacier Lake Camp. Lat. 28° 5' N.; 100° 45' E. Alt. 15,000 feet. On high cliffs and boulder screes of slate. A very pretty plant, 6 inches high or less,



Wardaster lanuginosus, J. Small.

the stems prostrate. Foliage very woolly. Ray bright lilac-violet, disc dull yellow." F. Kingdon Ward. No. 4686.

"I believe the plant is quite local and even rare. The region in which the plant was found is composed almost entirely of limestone, and there the 'flannel-leaved Aster' does not occur. There is, however, one range of slate, and it was on this short outcrop, a few miles in length, that the plant occurred; it was fairly common on that range (with *Myosotis Hookeri*, *Mecynopsis impedita*, *Primula rigida*, species of *Saussurea*, etc. etc.), but by no means abundant."

This new genus of Compositae is the "flannel-leaved Aster" mentioned on pp. 198-199 of *The Romance of Plant Hunting* (1). Although thus described as a possible Aster, it has close allies only in the *Alpigenia* section of that genus, of which *Aster alpinus* is a European representative. The general involucre characters of *Aster* here become considerably modified, the bracts being in a few rows and nearly equal in length.

While its taxonomic position is clearly in the second section of the Heterochrominae, near *Aster*, the new genus *Wardaster* shows affinities also with the Australasian *Celmisia* in just those characters, mucronate anther-bases and alveolate receptacle, which separate it so clearly from *Aster*. *Celmisia*, however, has the imbricated pluri-seriate involucre of the Asteroids, and also shows minor differences in the presence of shorter external setae in the pappus and silvery-silky indumentum, as well as the major geographical divergence. *Wardaster*, except for the involucre, might be described as a Chinese *Celmisia*. During the dissection of the disc florets, one or two anomalous florets with six anthers and six corolla lobes were observed. Although reduction in the number of parts is common, such increased numbers are rare in the Compositae.

The political or geographical status of its locality seems to be somewhat obscure. Glacier Lake Camp, according to Kingdon Ward, is reached from Muli thus: "Follow the Chung-tien road up the Rong chu to the crest of the spur, then turn off at right-angles up the valley, and hug the base of the cliff till you reach the top of the divide at 14,000 feet. Glacier Lake Camp and the slate range are now on your left front; on your right are the chimney-pots of the Muli cliff; and in front of you is a valley which leads down to Sholo" (1, p.

136). This locality lies technically in Szechuan, in a pocket of territory beyond the Yangtze River, in the Marches which lie on the borders of Yunnan and Szechuan with the Tibetan frontier to the west. Maps vary as to the borders of the two provinces at this point, and the situation is illuminated by the discoverer of *Wardaster*, who describes (1, p. 140) how "Ostensibly the Kingdom (of Muli) is subject to the suzerainty of Ningyuan-fu, a prefecture in the province of Szechwan. But nobody minds Ningyuan-fu. As a matter of fact, that poltroon city lives in constant fear of the attentions of its neighbours, the Lolo and Mantzu tribes; so that nowadays Muli pays tribute to no one." "As regards trade, it is rather with Yunnan in the south than with Szechwan."

Wardaster lanuginosus may be regarded from an evolutionary point of view as an *Aster* which has developed extreme woolliness as a protection against the vicissitudes of life on the storm-swept, snow-covered scree so graphically described in the above-mentioned volume. Having this dense covering of hair, the capitulum no longer requires the shorter protective involucre scales of the typical *Aster*, and these may have disappeared in much the same caducous fashion as the cauline leaves do in dried specimens. The mucronate anther-bases seem to be a common spontaneous mutant character, and the alveolate receptacle, by retaining the cypselas longer than usual within the involucre, would give them a chance to ripen fully before leaving their flannel-wrapped parent.

The new genus comes from the same district, "Mu-li mountains, S.W. Szechwan," as *Parasenecio Forrestii*, another new genus described by Professor Wright Smith and the present writer (2), who is indebted to the former for the opportunity of examining and describing this further interesting addition to the Compositae.

The generic name which has been given is in honour of the enthusiast who discovered the plant, F. Kingdon Ward, one of the foremost of the little band of collectors who have explored botanically these remote corners of China; and it has been so compounded that his opinion of its systematic position, which has proved to be so accurate, is also retained. The specific name is purely descriptive.

REFERENCES.

- (1) The Romance of Plant Hunting, by F. Kingdon Ward. Edwin Arnold & Co., London, 1924.
- (2) Trans. Bot. Soc. Edin., vol. xxviii, pt. iii (1922), p. 93.

DESCRIPTION OF FIGURES.

- FIG. 1.—General habit of *Wardaster lanuginosus*, showing a main rosette, A, with two flowering stems; B, a rosette with the leaves removed; and C, a rosette terminal on a stolon. The woolliness of the leaves is not indicated.
- FIG. 2.—Ray floret, showing the three-toothed tip of the corolla, the hairy flattened cypsela with two nerves or vascular strands.
- FIG. 3.—Disc floret.
- FIG. 4.—Upper part of one pappus hair.
- FIG. 5.—External view of the involucre bracts with the woolly indumentum scraped off.
- FIG. 6.—Alveolate receptacle: A, a general view; B, one alveole on a larger scale to show wavy edge.
- FIG. 7.—Style, showing short apical appendages and marginal stigmatic lines.
- FIG. 8.—Two stamens, each showing apical appendage, pollen sacs, basal appendages, "article anthérifère," and top of filament.
- FIG. 9.—A, apical appendage of anther; B, basal appendages with muricate tissue of "article anthérifère" between.

THE STRUCTURE AND DEVELOPMENT OF THE STAMEN IN *ERICA*
HIRTIFLORA. By J. R. MATTHEWS and GEORGE TAYLOR.

(Read 18th February 1926.)

The structure of the Angiospermic stamen, especially the antherine portion of it, has been the subject of repeated investigation. The earlier writers were concerned with morphological interpretations in terms of a foliar organ, and a useful review is given by Oliver (1861). In 1870 Chatin published his classic memoir, *L'Anthère*, in which a wide survey of structure is made, together with a study of the mechanism of dehiscence. More recent literature on the subject is conveniently summarised in such general text-books as Coulter and Chamberlain's *Morphology of Angiosperms*, Goebel's *Outlines of Classification and Special Morphology*, and *Organography of Plants*, while Haberlandt in his *Physiological Plant Anatomy* gives a résumé of the several views which have been advanced regarding the actual mechanism involved in dehiscence—a controversial question that has been re-opened recently by Woycicki (1924).

Much of the published work relates to what may be called the normal or typical stamen, consisting of a simple filament prolonged upwards into the anther to form the connective on either side of which lie the anther lobes with their embedded pollen-sacs. Dehiscence is effected usually by two longitudinal slits which appear in the mature anther as a result of differential shrinkage in a hypodermal mechanical layer. Deviations from the ordinary type are frequent, however, and not a few families of flowering plants are marked by some peculiarity of staminal structure. The Ericaceae furnish an example; and although the general morphology is known, histological details have not received much attention. Dehiscence by apical slits with which there seems to be associated, according to Leclerc du Sablon (1885) and Artopoeus (1903), the general absence of a fibrous layer, and the frequent occurrence of appendages, are features of the ericoid stamen that may best be interpreted by a study of development. *Erica hirtiflora*, one of the commonest Cape heaths in cultivation, has been selected for investigation.

The plant is a small shrub one to two feet high, branching freely, and bearing clustered inflorescences of pale purple flowers on dwarf lateral shoots. The urceolate corolla, about 4 mm. long, completely invests the androecium, the members of which are provided with two rigid spurs or appendages which project obliquely backwards towards the corolla tube. Below

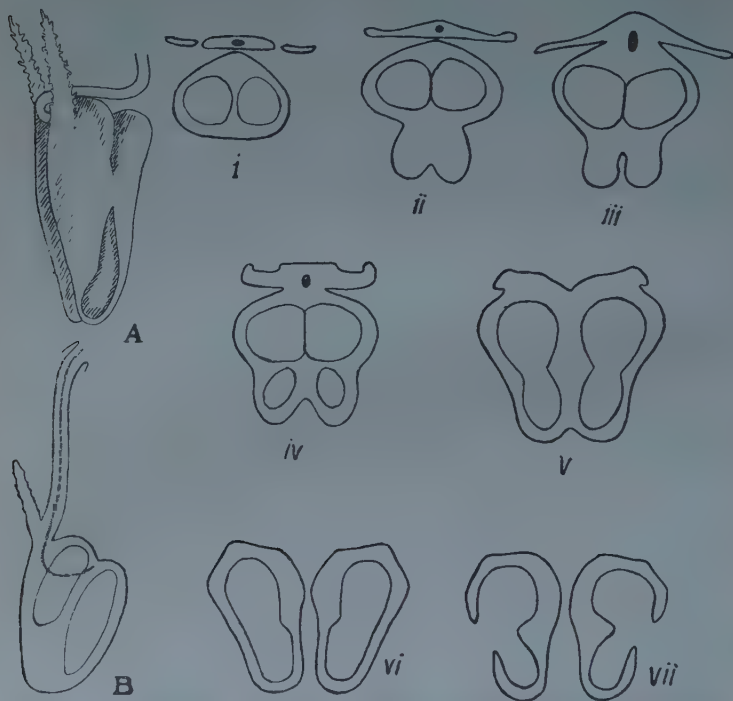


FIG. 1.—A, side view of anther of *Erica hirtiflora* showing dorsal spurs and apical slit; B, vertical section of anther to show vascular hook; i-vii, transverse sections of anther numbered from base to apex.

its point of attachment to the anther the filament is much flattened, and describes a double curve so that for a portion of its length the filament is placed in a horizontal position (fig. 1, A). The arrangement seems to provide a balancing spring for the anther in the pendulous flower, and may find its biological explanation in the trigger mechanism of pollination described by Church (1908). The mature anther opens by two apical slits which extend about half the length of the anther lobes. As in other Ericaceae the pollen grains

remain in tetrads, and upon a shaking process depends their removal from the pollen sacs.

The development of the flower of *Erica hirtiflora* does not differ in any important respect from that described by Payer

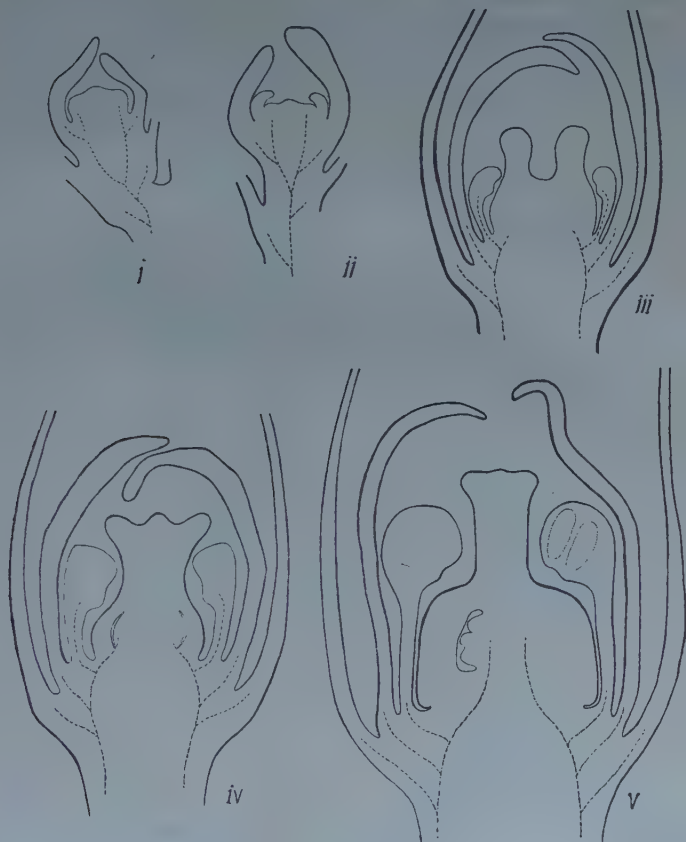


FIG. 2, i-v.—Vertical sections of the flower of *E. hirtiflora* showing successive stages in development (all $\times 81$).

(1857) for *E. cylindrica*, or by Church (1908) for *E. carnea*. A vertical section through a young bud shows the meristematic apex of the flower axis already invested by the over-arching sepals which form an open dome covering the growing point, and into which the remaining whorls of floral members arise in succession (fig. 2, i-v). Some of Church's drawings show a slight emargination at the base of the anther—a feature which

is depicted also by Payer, who states *le développement est fort singulier*, but no account of the peculiarity is submitted. This indentation makes its appearance quite early in the history of the anther (fig. 2, iii), and only at a later stage (fig. 2, v) does it occupy an apparently basal position. According to Artopoeus this emarginate base of the anther lobe in *Erica* and other members of the family is, in reality, the organic apex of the anther. The anther becomes inverted during development.

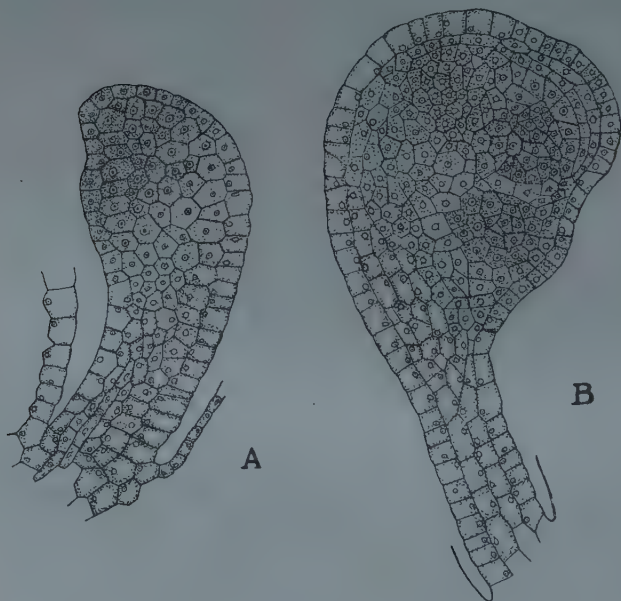


FIG. 3.—A, vertical section of single lobe of young stamen showing slight curvature ($\times 450$); B, an older stage where the curvature of the anther is more pronounced ($\times 386$).

We have confirmed the observations made by Artopoeus, and present some histological details which are lacking in his work.

The young stamen appears as a slightly curved, clavate body, the curvature being the result of more rapid growth on the dorsal side (fig. 3, A). Already there is an indication of the component parts of the stamen. As the organ develops growth is most active in the distal portion destined to form the anther (fig. 3, B), and throughout the early period of differentiation the body of the anther undergoes inversion (fig. 3). The final stage has been reached by the time the spore

mother cells have been defined (fig. 4). The curvature of the growing anther is clearly the result of more rapid growth on the dorsal side, as indicated by the size and vacuolisation of the epidermal and hypodermal cells on this side. As the curvature becomes pronounced (fig. 3, B) there can be recognised within each anther lobe two regions of cell activity which indicate the position of the dorsal and ventral archesporial tracts. Between

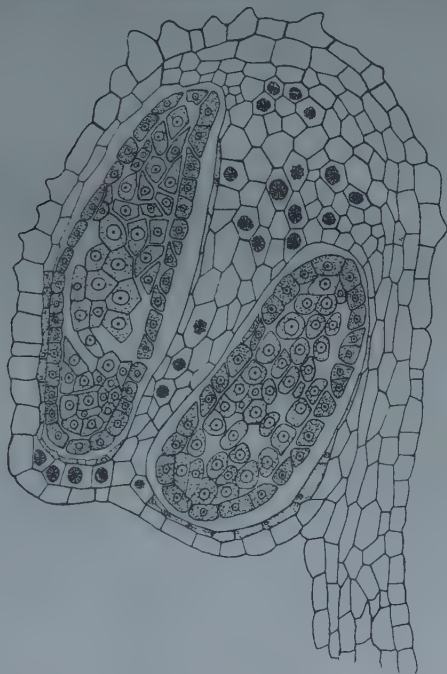


FIG. 4.—Vertical section of anther at spore-mother-cell stage. The anther is completely inverted. A portion of an appendage is seen ($\times 244$).

them there is a slight depression in the anther wall which broadens as the anther grows. It marks, topographically, the organic apex of the structure, although in the mature stamen, where it is readily recognisable, it occupies a position which is apparently basal. Thus in the anther of the ericoid stamen the morphological apex is at the base, and the so-called apical pores are really basal (fig. 1, A).

As already stated, the sporogenous bands are initiated while the anther is becoming inverted. They are seen in fig. 3, B,

as two small groups of cells occupying the bulges on the ventral side. Their gradual extension backwards until they reach the stage shown in fig. 4 depends upon the continued growth of the basal tissue of the anther. The parietal tissue, including the epidermis, consists of three to four layers of cells, and the innermost layer gives rise to the tapetum. By the time the anther is mature most of the hypodermal tissue, along with the tapetum, has broken down, and the pollen tetrads lie free in the pollen sacs. The septa dividing these in each anther lobe collapse, except in the lower part of the anther, which remains quadrilocular. Towards the "base" of the anther the dorsally placed sacs persist for some little distance after the ventral sacs have disappeared (fig. 1, i-v).

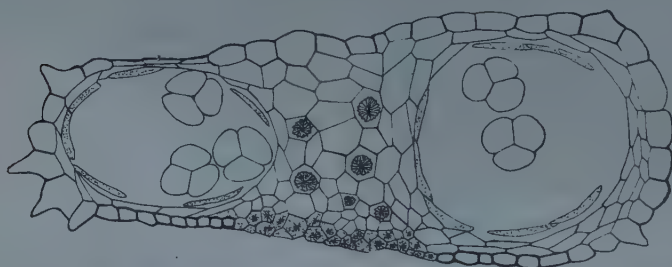


FIG. 5.—Transverse section of a single anther lobe with fully developed tetrads. Resorption tissue, dotted, contains small crystals of calcium oxalate, and larger crystals occur in the cells of the septum ($\times 344$).

The anther wall develops no fibrous layer, and dehiscence seems to depend primarily on the dissolution of tissue in the upper part of the anther lobes, resulting finally in the formation of the pair of elliptical pores with which the ripe anther is provided. The pores arise laterally (fig. 1, A and vii), and their place of origin can be detected before the pollen mother cells are defined. At this stage a transverse section through the anther lobe in the region of the pore is roughly oblong in outline. At the corners and on one side the epidermal layer consists of relatively large vacuolated cells, but on the other side, where the opening is ultimately formed, the cells are smaller (fig. 5). Those opposite the sacs have thickened walls; those opposite the partition between the sacs are thin-walled, and have abundant contents. It is this tissue occupying the middle of the flattened side opposite the partition that first begins to disintegrate, thus initiating the pore. It is the re-

sorption tissue of *Artopoeus*. The process of disintegration gradually extends inwards, involving the tissue of the septum between the sacs so that they become thrown together into one cavity. But the amount of tissue in the wall of the anther which breaks down to form the pore is limited. The opening is circumscribed by the thick-walled cells of the epidermis, and it is this thickening in the lower portion of the anther wall which limits the downward extension of the slit. In the dehiscent anther the indurated epidermal layer round the pore consists of cells whose outer tangential walls are slightly thicker than the inner, so that the valves tend to curl inwards.

Actual anthesis, then, is not associated with the development of a definite hygroscopic mechanism located in a fibrous layer. There is no mechanical rupture. The disintegration of a portion of the antherine tissue to form the pore seems to depend on the action of oxalic acid on the protoplasm and on the thin cellulose walls of the tissue where the pore arises. When the pollen mother cells are defined many of the cells of the anther, especially in the connective tissue, are found to contain crystals of calcium oxalate (fig. 4); and in the older anther, as preparation for dehiscence begins, the thin-walled cells of the epidermis in the region of the suture, and also the cells of the hypodermal layer, show granular contents as well as small crystals of calcium oxalate (fig. 5). Namakawa (1919) has described the opening of the anther in certain *Solanaceae* as due to the destructive effects of oxalic acid on the tissues underlying the suture, and it is probable that a similar condition holds for *Erica*, where, however, the epidermis itself forms part of the "disjunctive tissue."

The appendages with which the mature stamen is provided are a late development, for not until the sporogenous tracts are defined do they make their appearance. They arise from the tissue of the connective, and are prolonged dorsally for a short distance as thickened ridges on the back of the anther. Traced towards their free extremities the spurs are found to remain attached to the margins of the flattened filament after the filament is itself free from the anther. At a slightly lower level they become separate from the filament (fig. 1, i-v). The outgrowths may be described, therefore, as filamentous. Their rigidity depends upon a core of sclerenchymatous tissue which runs throughout their whole length.

A single vascular strand supplies the anther. Differentiated from the tissue of the connective it undergoes the same curvature as does the whole organ. In the mature stamen the strand is seen to pass from the filament into the connective, where it immediately turns downwards towards the "base" of the anther; actually it is directed towards the morphological apex. Its course is indicated in fig. 1, B, and its position in transverse sections in fig. 1, i-iv.

From the foregoing account it will be gathered that the ericoid stamen departs from the normal type in several important respects. The most remarkable feature is the inversion of the anther during development; and related to this, in all probability, is the early separation of the stamen into its component parts. Again, the mode of dehiscence is distinctive, and the limitation of the vertical slits to the upper part of the anther lobes seems a specialised condition to be interpreted in terms of the biological requirements connected with the presentation of pollen to visiting insects. But the stages which the stamen passes through during development are not unlike those which have been defined by M'Lean Thompson (1922). The first phase of *initiation* occurs when the primordium of the stamen is defined. This is followed by *differentiation* of the component parts involving in the ericoid type a considerable extension of the filament and the inversion of the anther. The third phase of *extension* is marked by the final elongation of the filament and dehiscence of the anther.

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THE COMPARATIVE MORPHOLOGY OF THE STAMEN IN THE
ERICACEAE. By J. R. MATTHEWS and E. M. KNOX.

(Read 18th February 1926.)

Divergent views have been expressed as to the exact limits of the family Ericaceae, but whatever grouping be adopted, there is general agreement that the whole assemblage of plants having an Ericoid affinity represents a relatively primitive series of sympetalous dicotyledons. As defined by Drude (1897) the family includes Rhododendroideae, Arbutoideae, Vaccinoideae, and Ericoideae, but Bentham and Hooker (1876) and Hutchinson (1926) separate Vacciniaceae as a distinct family. The Pyrolaceae and Monotropaceae, regarded by some authors as separate families also, have been shown by Henderson (1919) to differ from the Ericaceae only in their gradually increasing saprophytism and in a few minor characters associated with this habit.

In a large family any phylogenetic scheme must take into account all characters large or small, and while the structure of the stamen is but one aspect of floral morphology, sometimes relatively unimportant, in certain families it may be almost diagnostic. An example is provided by the Ericaceae. The peculiar type of stamen in this family has been the subject of several investigations. Chatin (1870), Leclerc du Sablon (1885), and others have dealt with it, but the most complete account is that of Artopoeus (1903). Our own observations have been confined almost entirely to members of the family as defined by Drude, and in presenting our results we follow his systematic arrangement.

Throughout the family the sympetalous condition of the corolla prevails, yet polypetaly is not unknown. Relatively primitive features are seen also in the retention of diplostemony and the toral insertion of the androecium. The advance to epigyny is confined to the Vaccinoideae, and it is of interest, therefore, that the closely related Epacridaceae, while retaining hypogyny, have progressed to epipetaly and isomery. But if the androecium in the Ericaceae lacks the biological advantages which arise from epipetaly, so common in sympetalous dicotyledons, its members are not wanting in

specialisation in other directions. There is great variety in the form of the stamen, a frequent development of appendages and a strong tendency toward terminal dehiscence of the anther. Associated with this so-called porose dehiscence is the absence in the wall of the anther of a well-marked fibrous layer, the function of which may be relegated to other tissues. Actual anthesis seems to be effected in a variety of ways. There is evidence also that sterilisation of an originally wholly fertile anther has been brought about in varying degree. This feature especially, and, indeed, the androecial equipment of the Ericaceous flower as a whole, seems closely related to the biological requirements connected with pollen presentation.

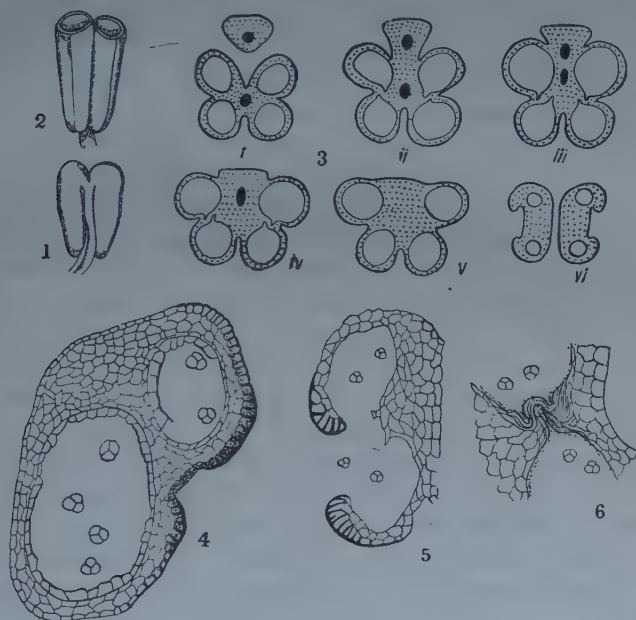
The ontogeny of the stamen in the Ericaceae has been described by Artopoulos (1903) and by Matthews and Taylor (1926). We have traced the development also in *Erica arborea*, Linn. The most striking feature is the complete inversion of the anther during its growth so that the real organic apex appears at the base of the adult structure. This fact would not be obvious from a study of the mature organ, and its discovery adds support to the contention of Thompson (1924) that ontogenetic studies are essential to a complete understanding of adult structure. It is a noteworthy feature, however, that in nearly all the cases investigated the vascular strand in the anther is in the form of a hook, the distal end being turned downwards in the tissue of the connective and becoming evanescent towards the apparent base of the anther (fig. 9). This curvature of the vascular strand follows upon the curvature which the anther itself undergoes during development. In *Rhododendron* (figs. 1 and 2) the external form does suggest something of this peculiar condition, for here the apparent base of the anther is somewhat narrow and pointed, while the apparent apex, where the pores are situated, is relatively broad. Thus, in the Ericaceae, the so-called apical pores of the anther are really basal.

But this paper deals mainly with the general morphology and anatomy of the adult stamen, and it will be convenient for purposes of description to refer to the several parts of the mature organ in those terms which are in general use. We shall speak of the pores as apical, the opposite end of the anther as basal, but it should be remembered that this is

not in accord with the true morphological state as determined by ontogenetic study.

RHODODENDROIDEAE.

This group includes the more primitive members of the family, and we have examined the staminal structure in a considerable number of genera, including *Ledum*, *Rhododen-*



FIGS. 1-6.—*Rhododendron* spp. Fig. 1, dorsal view of anther of *R. arboreum* ($\times 5$); fig. 2, face view of same ($\times 8$); fig. 3, series of transverse sections of anther numbered from base to apex ($\times 28$); fig. 4, tangential section through pore of one anther lobe of *R. Thomsoni* before dehiscence ($\times 50$); fig. 5, after dehiscence ($\times 50$); fig. 6, transverse section to show partition between pollen sacs in anther lobe ($\times 50$).

dron, *Loiseleuria*, *Kalmia*, *Phyllodoce*, and *Daboecia*. Details will be given for four of these. In all the genera the stamens are without appendages.

RHODODENDRON.—This genus exhibits a wide variety in flower form. The flower is more or less zygomorphic, and the androecium consists of a variable number of stamens, frequently more than ten. The long filaments, placed horizontally in the flower, curve upwards to bear distally small anthers in

an almost vertical position. The anther is dorsifixed, being attached near its base, middle, or, as in *R. arboreum*, Sm., towards its summit (fig. 1). The vascular strand which supplies the stamen passes along the filament and, at the point of attachment of the anther, enters the tissue of the connective, where it curves downwards towards the base of the anther. There is no vascular supply to the upper part of the anther. The relationships as seen in transverse sections are shown in fig. 3, i-vi. The same arrangement holds for *Ledum*, *Phyllodoce*, and *Kalmia*.

Dehiscence of the anther in *Rhododendron* is effected by means of an apical pore developed at the summit of each lobe (figs. 2 and 3, vi). At an early stage, the pore is marked by a circular plate of delicate tissue, surrounded by a thickened rim formed from cells of the epidermis (fig. 4). In some species this indurated border which encircles the pore is different in colour from the rest of the anther, and an unusually sharp definition is given to the pore. Of all the genera investigated *Rhododendron* affords one of the best examples of poricidal dehiscence.

The opening at the apex of each anther lobe arises from the subsidence and collapse of the thin plate of tissue which lies within the thickened border. This collapse is the result of a pull from below, brought about by the contraction of cells forming a part of the septum between the pollen sacs in each lobe. The partition becomes folded throughout a length approximately half that of the whole anther (fig. 3, ii-iv), and along this fold the cells are much contorted and compressed (fig. 6). The contraction results finally in the breaking down of the tissue of the septum, and the pollen sacs of each lobe are thrown together into a common cavity (fig. 5). Thus, dehiscence of the anther is not due, primarily, to a hygroscopic mechanism located in a hypodermal fibrous layer. There is no thickened endothecium. But hygroscopic movements of the epidermis may assist in dehiscence, since the distribution of the thickening of the cell walls is such that the free margin of the indurated epidermal rim tends to curl inwards (fig. 5). The movement will play a part in anthesis in so far as it aids in securing the complete rupture of the delicate epidermal covering which forms the suture.

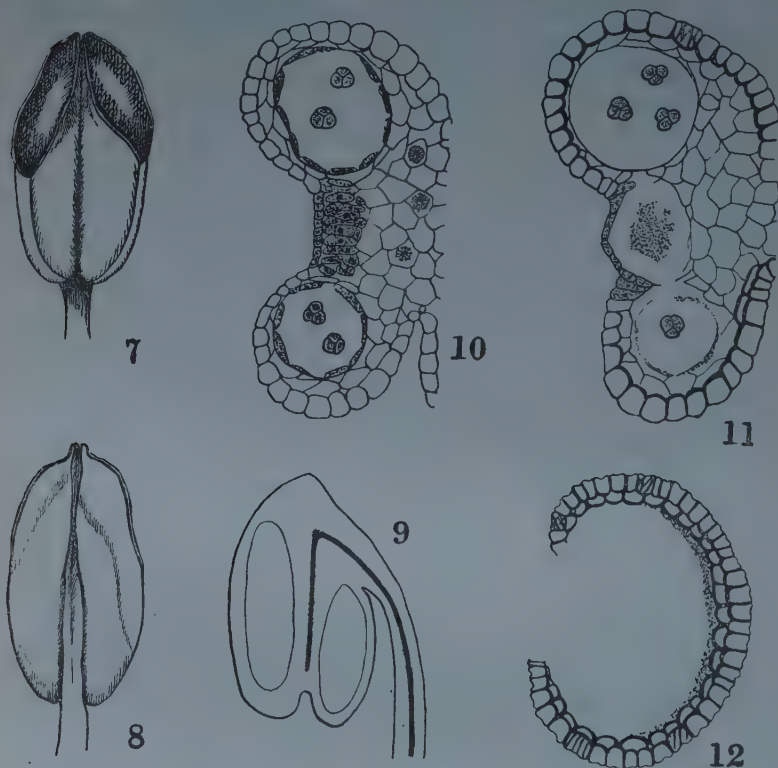
In *Rhododendron*, as in other Ericaceae, the pollen grains

remain in tetrads. These are not shed singly, however, but are held loosely by slender viscid threads, whereby numerous tetrads are removed from the ripe anther simultaneously. The condition seems to be a specialised one and is in striking contrast to the loose, powdery tetrads liberated by a shaking of the flower in the majority of the Ericaceae. The arrangement may find its biological explanation in connection with pollination of the relatively large, open, erect or semi-erect flower which is found in *Rhododendron*, whereas in most genera the flower is pendulous and the corolla more or less closed. The material from which the viscid threads are derived seems to be the small quantities of protoplasm left in the minute cavities which occur below each germ pore between the extine and intine of the pollen grain, but further investigation is necessary before a definite opinion can be expressed.

KALMIA.—Four species of *Kalmia* have been examined, *K. latifolia*, Linn. being selected for description. The flower is open, radial in construction, and remains erect or semi-erect in the inflorescence. The anthers are held fast in pouches of the corolla until a contact stimulus releases the elastic, outwardly-bent filaments, when they immediately spring forwards, discharging pollen through the relatively large apical fissures situated on the anther lobes (fig. 7). The filament is dorsifixed and is provided with a single vascular strand, the course of which is similar to that described for *Rhododendron*. Entering the connective of the anther the strand travels upwards for a short distance, then curving sharply downwards it descends towards the base of the anther (fig. 9).

The detailed structure of the anther and stages in the development of the vertical fissure which arises in the upper half of each lobe are shown in figs. 10–12. In the young anther the several tissues are composed of thin-walled cells, the place of dehiscence being marked by a group of small cells situated laterally between the two pollen sacs, and characterised by their dense granular contents (fig. 10). This is the resorption tissue of the anther described by Artopoeus. Since its disintegration plays a leading part in actual anthesis it may be described further as disjunctive tissue. In *Kalmia* it extends almost the whole length of the anther, and as the organ matures it is the resorption tissue which first undergoes dissolution, leading finally to the destruction of the broad parti-

tion which separates the pollen sacs (fig. 11). Artopoulos suggests that the disintegration process may be the result of enzyme action, but in view of the recent work of Namakawa (1919), it seems probable that oxalic acid, by destroying the



FIGS. 7-12.—*Kalmia latifolia*. Fig. 7, face view of anther ($\times 40$); fig. 8, dorsal view ($\times 40$); fig. 9, vertical section through filament and anther showing hook-like arrangement of vascular strand ($\times 40$); fig. 10, transverse section of anther showing one lobe in region of pore ($\times 136$); fig. 11, same as fig. 10 at older stage ($\times 136$); fig. 12, transverse section through pore of anther after dehiscence.

thin cellulose walls of the disjunctive tissue, plays a part in the dehiscence of the anther in *Kalmia* and other *Ericaceae*, as described by that author for certain *Solanaceae*. It is significant that crystals of calcium oxalate are present in many of the cells of the connective, and the granular material in the cells of the resorption tissue may be the same substance.

The small cells of the epidermis which form the stomium

do not break down immediately (fig. 11), and while their ultimate collapse may be due to the same causes which result in the disappearance of the resorption tissue, there seems little doubt that the rest of the epidermis, acting as a hygroscopic layer, contributes to the final separation of the valves of the anther to form a gaping fissure.

At the stage shown in fig. 11, before actual anthesis has occurred, the radial and inner tangential walls of the epidermal cells are already thickened, and one of the cells shows fibrous thickening. At the later stage shown in fig. 12, the hypodermal layer is also composed of thick-walled cells. The distribution of the thickening material is such that, as desiccation proceeds, the epidermis will tend to function as a hygroscopic mechanism leading to the rupture of the stomium and the separation of the anther valves.

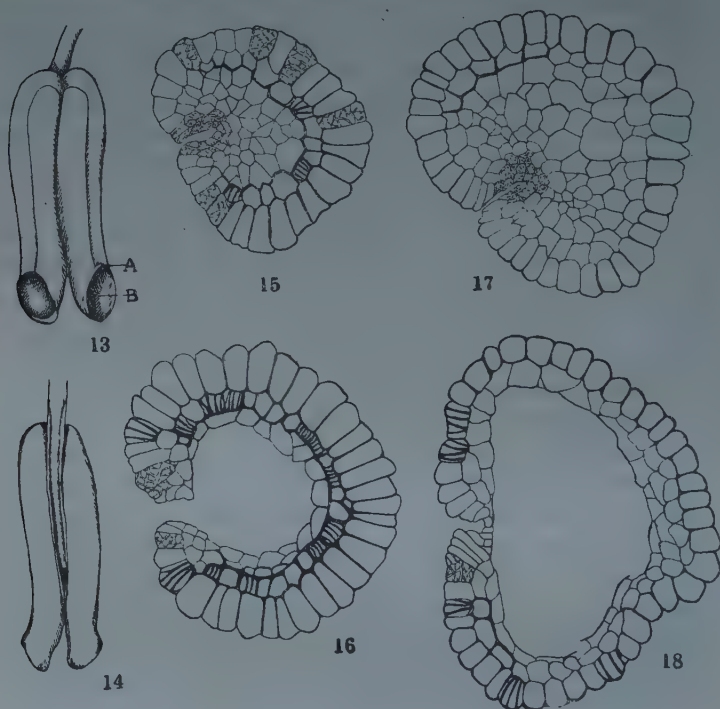
The localisation of the opening in the upper part of the anther depends upon the distribution of the indurated epidermal and hypodermal layers of the anther wall. In the lower part of the anther, the wall is formed of the epidermis only, the hypodermis being absent. Moreover, the epidermis is here composed of cells whose walls are almost uniformly thick, and while the stomium can be traced along the whole length of the anther, the opening mechanism becomes ineffective in the lower part. Thus, a structural difference in the wall of the anther may be held to be responsible for the limitation of the vertical fissure to the upper part of the lobe.

The general structure of the anther in *Kalmia* appears less specialised than in *Rhododendron*, and although a typical fibrous layer is absent, the arrangement for dehiscence is not so far removed from that which occurs in the normal angiospermic anther opening by longitudinal slits.

PHYLLODOCE CAERULEA, Bab. (*Bryanthus taxifolius*, A. Gray).—This serves to introduce the pendulous type of flower which is very general throughout the family. The corolla is ovoid-urceolate and encloses the stamens. The anther is adnate to the filament, and is provided with a single vascular strand which forms a hook in the tissue of the connective, as in *Rhododendron* and *Kalmia*. A deep longitudinal furrow runs along the face of each anther lobe forming a line of weakness, the upper end of which marks the position of the stomium. Dehiscence is by means of rounded openings

terminating the diverging lobes of the pendulous anther (fig. 13).

The pollen sacs do not extend to the summit of the anther. Fig. 15 shows a transverse section through the apex of a single lobe (corresponding to level B in fig. 13) before the beginning



FIGS. 13-18.—*Phyllodoce coerulea*. Fig. 13, face view of anther ($\times 22$); fig. 14, dorsal view ($\times 22$); fig. 15, transverse section through apical part of anther lobe showing structure in region of pore before dehiscence ($\times 175$); fig. 16, an older stage than fig. 15 showing the pore cavity ($\times 175$); fig. 17, transverse section through young anther taken below the level of the pore ($\times 175$); fig. 18, the same at an older stage ($\times 175$).

of anthesis. The central parenchyma tissue is bounded on the dorsal side by a well-defined hypodermal layer of cells with their inner tangential and radial walls thickened, while a few component cells show fibrous thickening. On the same side, the epidermis consists of radially elongated cells, some of which have a reticulate thickening of the walls. On the ventral side, the epidermis curves inwards and a narrow groove is formed. The cells bordering this furrow are small, thin-

walled, and contain a granular material. They form the resorption tissue, which extends along the length of the anther lobe, and although it is less evident towards the base of the lobe, it is still a conspicuous feature below the pore as is shown in fig. 17, which is drawn from a section cut at the level marked A in fig. 13.

As the anther matures the resorption tissue gradually breaks down, and in the region of the pore the bulk of the central thin-walled parenchyma is ultimately destroyed. This gives rise to the pore cavity shown in fig. 16. But the separation of the anther valves seems to depend upon a genuine hygroscopic movement. A ripe anther allowed to dry begins to split along each lobe from the apex downwards, after the manner of a follicular fruit. The opening follows the line of the furrow, and the split may be induced to extend the whole length of the anther lobe. But normally it does not extend far, and, as in *Kalmia*, the limitation of the pore appears to be dependent upon structural differences in the wall of the anther. Fig. 16 is drawn from a transverse section cut through the pore region of a mature anther, and represents an older stage than that shown in fig. 15. The resorption tissue and most of the central parenchyma have disappeared. Although more or less interrupted, the hypodermis forms an unmistakable fibrous layer, and in some sections through the pore almost all its cells show fibrous thickenings. Thus constituted, the upper part of the anther wall in *Phyllodoce* does not differ in any important respect from the ordinary angiospermic type.

But this structure does not hold throughout. It occurs only in the region of the pore. Below the pore level the epidermis is continuous, and the opening is closed by a band of small thin-walled cells (fig. 18). These form the line of weakness along the anther lobe to which reference has already been made. That they do not normally break depends upon the absence of any subepidermal mechanical layer. Although a few scattered cells with fibrous thickenings occur in the epidermis, they do not appear to effect complete longitudinal dehiscence of the anther. The conclusion may be reached, therefore, that the restriction of the pore to the apical part of the anther in *Phyllodoce* is related to structural features of the anther wall, and especially to the distribution of the

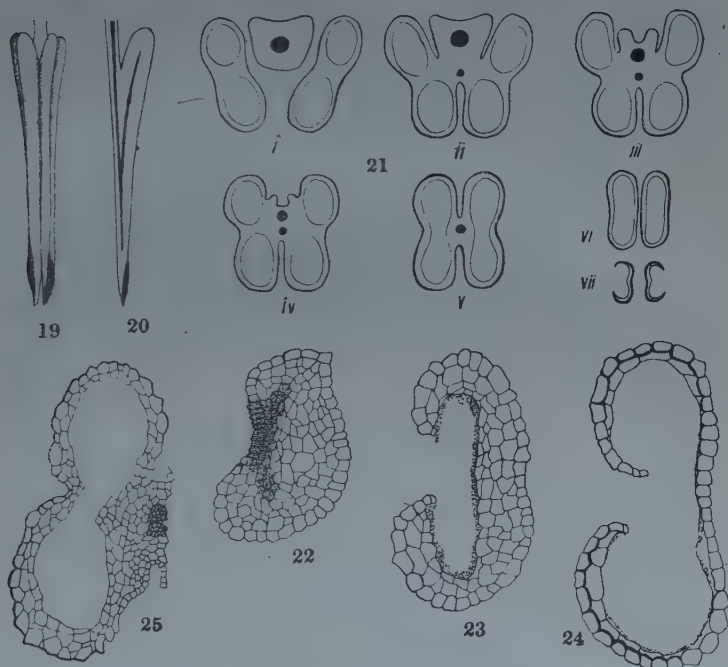
fibrous layer. - The typical endothecium has not been lost entirely, but it is confined to that part of the anther where the pores develop. It is there associated with resorption tissue, the dissolution of which initiates the pore and forms a connection with the pollen sacs below. The structure may be regarded as derivative, while terminal openings to the anther will allow of a gradual pollen-sprinkling process in a pendulous flower.

DABOECIA POLIFOLIA, D. Don.—Here again the flower is pendant and the ovate suburceolate corolla encloses the stamens. The anther is relatively long and tapers towards the apex, where the thecae diverge slightly. Dehiscence is by an apical slit in each lobe (fig. 19), the pollen presentation area lying within the mouth of the corolla tube.

A single vascular strand enters the anther from the filament. It passes through the connective to the middle of the anther, where it bends sharply backwards and ends near the base of the anther. A subsidiary strand appearing as a continuation of the main vascular tract is directed upwards, supplying the terminal portion of the anther, which is sporogenous almost to the apex (figs. 20 and 21, i-v). Successive stages in the development of the pore are shown in figs. 22-24, which are drawn from sections cut at the same level. The sporogenous tracts do not extend to the apex of the anther, the tissue in the region of the pore being sterile. Before the apical slit has been initiated (fig. 22) the tissue concerned shows two distinct areas, that on the ventral side being distinguished by the dense granular contents of the cells. This is the resorption tissue, and, where the pore arises, it forms a crescent-shaped band and includes a portion of the epidermis. Below the level of the pore the band straightens out, withdraws from the epidermis, and connects across the septum with the two pollen sacs of the anther lobe. It does not, however, extend downwards throughout the whole length of the anther. Minute crystals occur in many of the cells of the resorption tissue, and larger crystals appear occasionally in the cells of the connective. Probably they are formed of calcium oxalate.

As the anther matures the resorption tissue begins to disintegrate. The cell walls disappear and the slit in its initial stages is full of granular material, some of which is still seen at the stage shown in fig. 23. The destructive process con-

tinues until finally little of the tissue remains except the epidermal layer (fig. 24). There is no trace of an endothecium with characteristic fibrous thickenings, but, in the ripe anther, the epidermis, which practically constitutes the wall in the region of the pore, is composed of cells having their inner tangential walls conspicuously thickened. The slit has already



FIGS. 19-25.—*Daboecia polifolia*. Fig. 19, face view of anther ($\times 7$); fig. 20, vertical section of anther showing vascular system ($\times 7$); fig. 21, i-vii, series of transverse sections of anther from base to apex ($\times 30$); figs. 22-24, transverse sections of the apex of anther lobe showing successive stages in development of the pore (all $\times 175$); fig. 25, transverse section of anther lobe cut about the level of fig. 21, iv ($\times 85$).

been established, however, before this differentiation is completed. Below the level of the opening, the wall of the anther is composed of several layers, and the thickening of the epidermal cells is transferred to the outer walls. Thus, upon these structural changes in the wall, and upon the peculiar distribution of the resorption tissue, depends the restriction of the slit to an apical position.

In the complete absence of a fibrous layer, *Daboecia* shows

a greater deviation from typical antherine structure than does *Kalmia* or *Phyllodoce*. Among the *Rhododendroideae*, these two genera are considered relatively more primitive, and their retention of a fibrous layer or its functional equivalent, at least in that part of the anther concerned with dehiscence, is a further indication of a limited specialisation. In *Daboecia* greater dependence seems to be placed upon the specialised resorption tissue. On the other hand, in *Rhododendron*, specialisation appears to have proceeded along somewhat different lines. The precision with which the apical pores are formed and the removal of pollen in masses are features which seem peculiarly fitted to secure pollination in the open, horizontal flower with spreading stamens. The assumption of the pendulous flower habit, which appears in *Phyllodoce* and in *Daboecia*, and which is prevalent throughout the remaining three subfamilies, presents a different problem in the presentation of pollen. The arrangement which is seen in these two genera prepares the way for the condition which characterises the family as a whole.

ARBUTOIDEAE.

In this subfamily the corolla is generally urceolate in outline and encloses the stamens, which are often furnished with bristle-like appendages. There are about twenty genera, of which we have examined *Enkyanthus*, *Andromeda*, *Pieris*, *Gaultheria*, *Pernettya*, *Arbutus*, and *Arctostaphylos*. Four are selected for description.

PIERIS.—Taxonomic works invariably refer to the staminal appendages which characterise many of the genera of *Ericaceae*, but little precision has been given to the position or morphological value of these processes. The anther is often described as spurred, but not infrequently the spurs are referred to the filament. The distinction may be small, but it is one which has been employed recently by Rehder (1924) in the discrimination of certain genera. This writer claims that appendages to the filament are not equal in taxonomic importance to the awns on the anther. The former condition is regarded as less constant, the appendages tending to become indistinct or even obsolete, while the awned anthers constitute a constant and important character. Since Rehder's paper deals mainly with the genus *Pieris*, we have extended our survey of the stamen

over a considerable number of species, confining the account to general morphological features rather than histological detail.

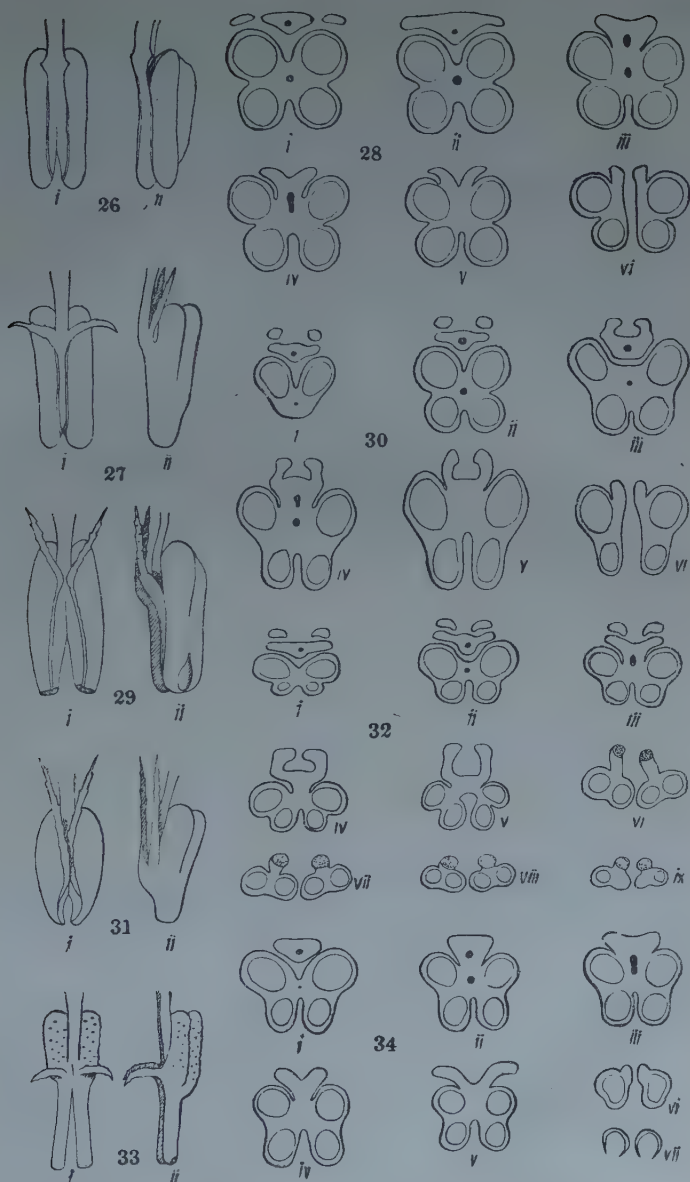
In the original description of the genus by Don (1834), the type of which is *Pieris formosa*, Don, the filaments are described as bisetose at the apex. It may be stated at once that this description is correct, despite a more recent account in the Botanical Magazine (1909), where the anthers are said to be spurred on the back. Systematists have admitted both conditions, and the genus as hitherto understood may show appendaged anthers or appendaged filaments. Rehder, however, proposes to restore the generic name *Xolisma*, Rafinesque for those species of *Pieris* which have spurs arising from the filament, retaining in the genus *Pieris* those forms which possess appendaged anthers. On this basis, *P. nitida*, B. and H., *P. mariana*, B. and H., *P. ovalifolia*, Don, *P. villosa*, Hook. f., *P. compta*, W. W. Sm. and J. F. J., and *P. bracteata*, W. W. Sm., are transferred to *Xolisma* as new combinations, while *P. Forrestii*, Harrow, *P. polita*, W. W. Sm. and J. F. J., *P. Bodinieri*, Lév., and *P. formosa*, Don are mentioned as examples of true *Pieris*. But the distinction between filamentous and antherine spurs is more apparent than real. In *P. ovalifolia* (fig. 27, i and ii) characteristic bristle-like appendages occur which are clearly filamentous, while in *P. bracteata* (fig. 33, i and ii) the short, rigid spurs seem to be as clearly antherine. Between these two apparently extreme conditions falls the whole series we have examined. The series is as follows:—

<i>Name of species.</i>	<i>Position of appendages.</i>
<i>P. villosa</i> , Hook. f.	Near apex of filament, very small.
<i>P. ovalifolia</i> , Don	Near apex of filament.
<i>P. Doyanensis</i> , Handel-Mazzetti	" "
<i>P. compta</i> , W. W. Sm. and J. F. J.	" "
<i>P. mariana</i> , B. and H.	" "
<i>P. nitida</i> , B. and H.	At apex of filament.
<i>P. Swinhoei</i> , Hemsl.	At apex of filament, very small.
<i>P. floribunda</i> , B. and H.	At apex of filament.
<i>P. formosa</i> , Don	" "
<i>P. Forrestii</i> , Harrow	" "
<i>P. phillyreaefolia</i> , Hook.	" "
<i>P. Bodinieri</i> , Lév.	" "
<i>P. taiwanensis</i> , Hayata	Apparently antherine.
<i>P. polita</i> , W. W. Sm. and J. F. J.	" "
<i>P. japonica</i> , Don	" "
<i>P. bracteata</i> , W. W. Sm.	" "

The species are here arranged progressively according to the position of the staminal outgrowths as determined macroscopically. In *P. villosa*, Hook. f. (fig. 26, i and ii) no characteristic spurs occur, and the slightly winged protuberances near the apex of the filament may be regarded as appendages incipient or vestigial. But occupying a similar position in *P. ovalifolia*, Don typical muricate processes are developed (fig. 27, i and ii). These are present in all species examined, although they vary considerably in size. In position they range from insertion on the free portion of the filament, as in *P. ovalifolia*, Don, to insertion beyond the point of union of anther and filament, as in *P. bracteata*, W. W. Sm. (fig. 33, i and ii), where they appear to be attached to the anther lobes.

But any discussion of the exact point of origin of the appendages must include a consideration of the connective of the anther. The degree of union of the thecae varies, and in *P. bracteata*, W. W. Sm. the anther is bipartite in its upper half, the lobes resolving themselves into those tubular prolongations which are so striking a feature in many of the Vaccinoideae. Nevertheless, a connective is always present and is morphologically inseparable from the filament, being a prolongation of that structure between the thecae. Where the appendages are apparently antherine, they do not arise from the walls of the microsporangia but from the tissue of the connective. Thus, in *Pieris* (including *Xolisma*) one type of staminal structure holds throughout.

The general anatomical relationships may be gathered from figs. 28, 30, 32, and 34, which are drawn from serial sections of stamens of four representative species. In *P. ovalifolia*, Don (fig. 27, ii) the appendages are seen to be filamentous, being attached to the filament before the filament itself joins the anther (fig. 28, i and ii). The connective is relatively broad, and traced along the anther it is seen to become somewhat V-shaped, so that two projecting arms appear dorsally (fig. 28, iii-v). Followed in the opposite direction, the ridges of the connective may be described as expanding laterally to form a pair of spreading processes which do not project freely, however, until below the point of union of anther and filament. Examination of fig. 29, i and ii and fig. 30, i-vi shows that a similar condition holds for *P. Forrestii*, Harrow, although the



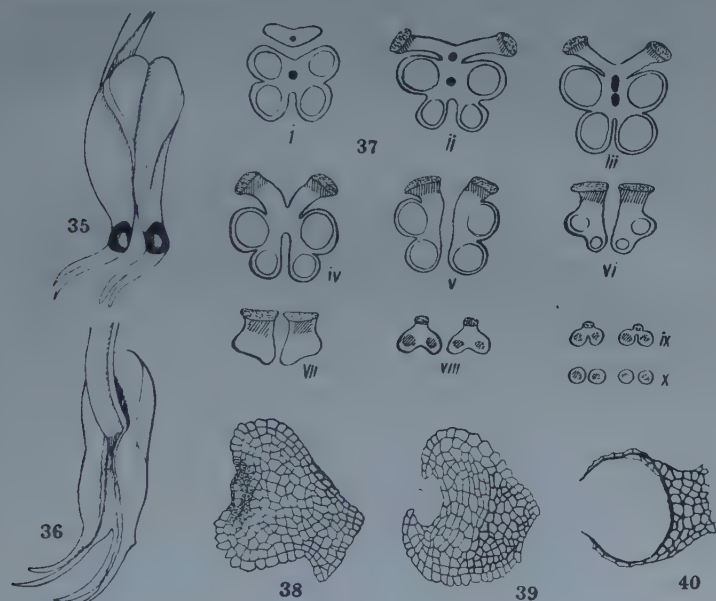
FIGS. 26-34.—*Pieris* spp. showing various forms of anther. Fig. 26, *P. villosa* ($\times 10$); figs. 27 and 28, *P. ovalifolia* ($\times 12$ and 25 respectively); figs. 29 and 30, *P. Forrestii* ($\times 15$ and 25 respectively); figs. 31 and 32, *P. japonica* ($\times 15$ and 25 respectively); figs. 33 and 34, *P. bracteata* ($\times 7$ and 25 respectively). For further description see text.

point of origin of the appendages is shifted a little further forwards, and the dorsal ridges of the anther are more pronounced. In *P. japonica*, Don (fig. 31, i and ii and fig. 32, i-ix) the anther is adnate where the appendages arise as free structures (fig. 32, iii), and the dorsal ridges very prominent. These ridges are carried along the back of each anther lobe beyond the divergence of the thecae, and their superficial tissue ultimately undergoes disintegration, leaving an accumulation of white powdery material. The shifting forward of the appendages is carried further in *P. bracteata*, W. W. Sm. (fig. 33, i and ii and fig. 34, i-vii), where they appear as laterally spreading outgrowths from the connective. The ridges are here less prominent, and the terminal portion of the anther forms two tubes which connect with the pollen sacs below and provide for liberation of the pollen by small apical slits (fig. 34, vi and vii). It is the condition of *P. japonica*, Don and *P. bracteata*, W. W. Sm. which suggests the origin of the staminal processes from the dorsal lobes of the anther and would seem to justify their description as antherine. But the appendages are either related to the filament or to the connective, and as such they are simply outgrowths of the microsporophyll. In *Pieris*, their position may be regarded as having become shifted successively nearer the apex of the structure which bears them, and the distinction between filamentous and antherine appendages, as employed by Rehder, has no real existence. The position and form of these outgrowths may prove of specific value; as generic characters between *Pieris* and *Xolisma* they have no real value.

GAULTHERIA.—This is the largest genus of the *Arbutoideae*. We have examined several species, but our description and figures refer to *G. procumbens*, Linn. The flower is pendulous, and the stamens are included within an ovoid corolla having a flat base and with the tube constricted at the throat. The form of the stamen is peculiar (figs. 35 and 36). The filament is inserted dorsally about the middle of the anther, the lobes of which diverge upwards and the distal part of the stamen appears as a pair of bifurcating processes. These claw-like structures constitute the staminal appendages, and directed backwards in the flower, they lie about the level of the constriction in the corolla tube, thus guarding the entrance. Circular openings on the ventral side of the anther lobes near

the base of the appendages provide for the liberation of pollen by shaking of the anthers in the pendant flower (fig. 35).

A single vascular strand supplies the stamen in *Gaultheria*. It passes from the filament into the connective, where it makes a downward curve to form a small hook, the arrangement being similar to that described for members of the *Rhododendroideae*.



FIGS. 35-40.—*Gaultheria procumbens*. Fig. 35, face view of anther ($\times 17$); fig. 36, dorsal view ($\times 17$); fig. 37, i-x, series of transverse sections of anther numbered from base to apex ($\times 25$); figs. 38-40, transverse sections of a single lobe showing successive stages in development of the pore (all $\times 170$).

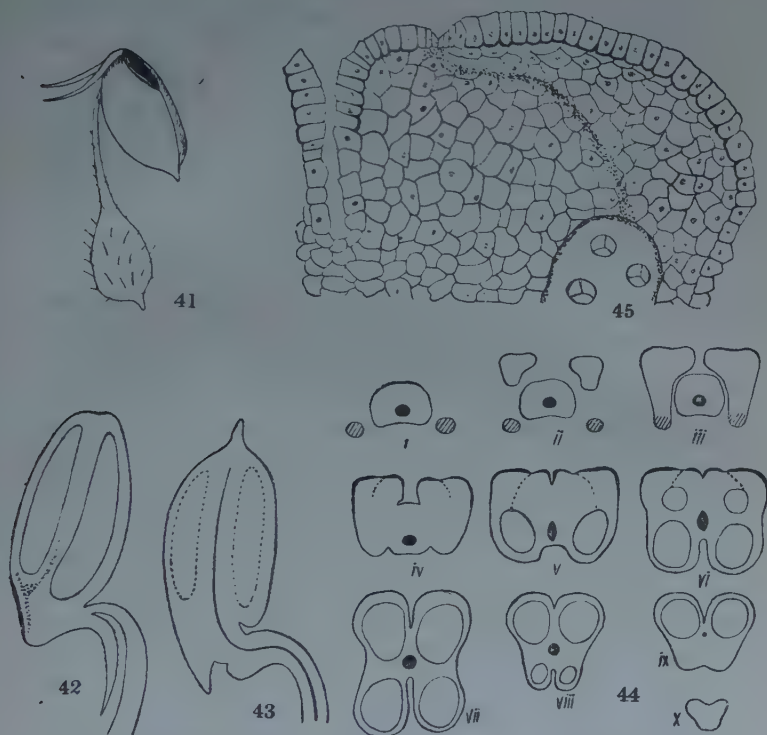
The filament at its union with the anther is broad and flat (fig. 37, i and ii). Traced upwards it resolves itself into two spreading arms, which form a V-shaped connective, and where the lobes of the anther diverge, each is seen to have one of the arms attached (fig. 37, iii-vi). In the young anther, the cells of the superficial tissue of these projecting ridges of the connective (excluding the epidermis) contain an abundant white granular substance, which disappears as the anther matures, its disappearance involving the disintegration of the tissue. The region involved is shown by stippling in fig. 37, ii-viii.

The adjacent tissue, shaded in the same drawings, differentiates as two sclerenchymatous bands which can be traced dorsally along the length of the anther beyond the fertile lobes into the terminal prolongations, where each band divides to form two strands which pass finally into the bifurcating appendages as solid cores of sclerenchyma. It is these sclerenchymatous rods that give rigidity to the appendages, which appear, therefore, as a resolution of the dorsal side of the anther having a peculiar form of connective, the component parts of which, remaining attached to each anther lobe, undergo a bifurcation and carry their branches beyond the sporogenous area.

Stages in the development of the opening leading to porose dehiscence of the anther are shown in figs. 38-40. The pore is formed at the level indicated in fig. 37, vii—that is, beyond the upper limit of the pollen sacs. A transverse section through this region is shown in fig. 38. In the young anther the lobe is here formed of thin-walled parenchyma, and on the ventral side, in the position of a slight depression, a small part of the tissue shows dense, granular cell-contents. This is the resorption tissue, and by its disintegration a small concavity is formed, thus initiating the pore (fig. 39). Meanwhile, the cell-walls of the dorsal tissue of the lobe have undergone thickening to form part of the sclerenchymatous band, which has been described above as extending dorsally along the whole length of the anther. At a later stage the concavity deepens and extends backwards as far as the sclerotic tissue (fig. 40). Around the opening only the epidermis remains, there being no trace of a fibrous layer. The structure throughout is highly modified, and the formation of the pore depends upon the destruction of a prepared thin-walled tissue, the extent of which is limited dorsally and to some extent laterally by the presence of a sclerenchymatous sheath.

ARBUTUS and ARCTOSTAPHYLOS.—These two genera are so closely allied that they may be taken together. In *Arbutus Unedo*, Linn., which we have examined particularly, the mature stamens are each provided with a pair of bristle-like outgrowths which point backwards towards the constriction of the urceolate corolla tube. Attachment of the individual stamen to the torus is by a slender point, but the filament broadens near its base, while upwards it again narrows to its point of insertion on the anther (fig. 41). The appendages

at the summit of the anther arise from the lobes and are not attached to the filament. In close proximity to the outgrowths are the relatively large elliptical pores, which in the



FIGS. 41-45.—*Arbutus Unedo*. Fig. 41, side view of mature stamen ($\times 7$); fig. 42, vertical section through lobe of young anther showing appendage, basal position of pore and resorption tissue dotted ($\times 20$); fig. 43, vertical section through connective of young anther showing articular at end of filament and course of vascular strand ($\times 20$); fig. 44, transverse sections of young anther cut from base to apex, the appendages in components i-iii shaded ($\times 25$); fig. 45, transverse section of part of anther lobe of *Arctostaphylos Manzanita* cut through region of dehiscence showing stomium and resorption band dotted ($\times 175$).

ripe anther are directed downwards in the pendulous position of the flower.

The true morphological relationships of the peculiar type of stamen in *Arbutus* can be understood only by following the ontogeny. During development the anther remains straight; there is no curvature in the early stages of growth

leading to that complete inversion of the anther which is characteristic of the family as a whole. The ordinary topography is at first maintained (fig. 43), and the single vascular strand entering from the filament travels vertically through the connective from base to apex, ending below a short but prominent apical beak with which the anther is provided. This beak marks the organic apex of the structure. The vertical position is maintained until the anther is fully organised, but a change in position is effected during those later phases of growth which culminate in flowering. The anther is hinged to the filament by a distinct articulus (fig. 43) and gradually swings through an angle of about 160° , until by the time of flowering it has become inverted and assumes the position shown in fig. 41. The apical beak is now directed downwards, and the pores, which are morphologically basal in position, appear to be apical.

The anther is thus a versatile one, and during its swinging movement it carries with it the appendages. These develop early as outgrowths on the ventral side of the basal tissue of the anther lobes. Fig. 42 shows a vertical section of a single lobe with the young appendage hanging parallel to the filament. In fig. 44, i-iii the position of the appendages is shown in transverse section, and their union with the anther lobes is seen to be completed before the centrally placed filament becomes fused to the anther.

The structure and development of the stamen in *Arctostaphylos* is essentially similar to that described for *Arbutus*. The appendages are longer and terminate in slender, hooked tips, but in the young stamen, while the anther is still erect, they are relatively short and hang down close to the filament. As the flower develops the versatile anther becomes inverted and the appendages assume a horizontal position. The appearances as seen at different ages have been figured by Knuth (1909) for *A. alpina*, Spreng.

The region where dehiscence of the anther will take place is determined early in development. It is indicated for *Arbutus Unedo*, Linn. in fig. 42 by the heavier outline in the lower part of the dorsal surface, and in fig. 44, iv-vi the position of this suture in transverse sections is seen as the slight depressions on the dorsal side of each lobe. The epidermis of the anther wall is here composed of radially elongated

cells, whose inner tangential walls are thickened early in development, except those cells which form the stomium, which are small and remain thin-walled. The structure as observed in *Arctostaphylos Manzanita*, Parry is shown in fig. 45. The epidermis of the flanks and ventral side of the anther lobes is formed of papillose cells, the walls of which are uniformly thickened. Actual anthesis is preceded by disintegration of the tissue underlying the stomium. This commences first in the resorption tissue, which forms a narrow band connecting the stomium with the dorsal pollen sac (figs. 44, vi and 45), and at a slightly lower level it connects also with the ventral sacs (fig. 44, v). By the dissolution of this tissue the sacs are not only thrown together, but they are also brought into relation with the stomium in the region of the pore. All the tissue underlying the pore becomes destroyed, and only the epidermis is left to form the wall of the anther. At this stage the inner tangential and radial walls of the epidermal cells have become considerably thickened, and rupture of the stomium seems to be determined by the epidermis acting as a hygroscopic layer. In the dehiscent anther the epidermis curls backwards to form the valves of the pore, and its cells are seen to be much compressed radially owing to the collapse of the thin outer tangential walls. The early development of the pore in *Arbutus* and *Arctostaphylos* is thus associated with those internal changes which commence in the resorption tissue, while the final opening is effected mechanically as a result of the structural differentiation of the epidermal layer of the anther wall.

VACCINOIDEAE.

The epigynous structure of the flower and the baccate fruit distinguish this from the other subfamilies of the Ericaceae. The stamens are frequently furnished with those spur-like appendages which occur commonly in the *Arbutoideae* and *Ericoideae*, but they are characterised further by the possession of antherine processes of a different nature, derived from the lobes of the anther itself, and appearing ultimately as tubular structures surmounting the fertile portion of the stamen. These processes may be described as awns to distinguish them from the bristle-like outgrowths or spurs already mentioned.

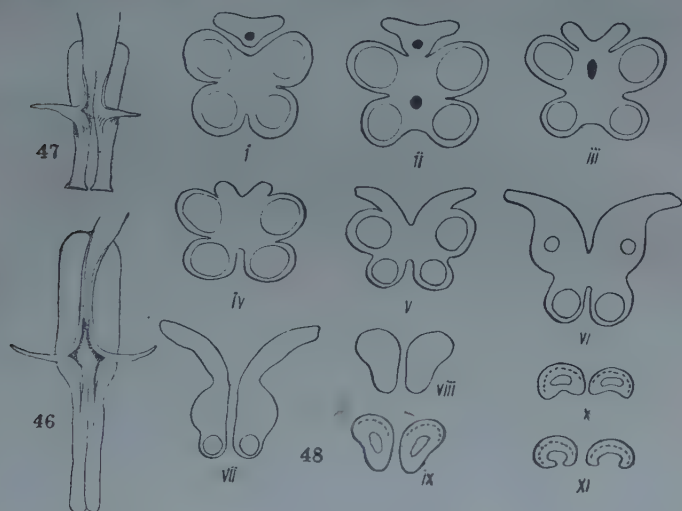
VACCINIUM.—As shown by Artopoeus (1903) for *Vaccinium Vitis Idaea*, Linn., the anther becomes inverted during development, and we have observed the same behaviour in *V. Myrtillus*, Linn. The feature is probably general throughout the subfamily, and the long, terminal, and apparently apical awns are, morphologically, prolongations of the base of the anther. The vascular supply is in the form of a curved strand embedded in the tissue of the connective, and the distal end, pointing towards the apparent base of the anther, is really directed towards the organic apex. An interesting condition is seen in *V. Myrtillus*, Linn. and *V. Vitis Idaea*, Linn., where a short ascending branch passes from the main supply into the upper (morphologically lower) part of the anther, recalling the arrangement described for *Daboecia*.

The general external morphology of the flower has been examined in about two dozen species. The corolla is commonly more or less closed, varying in shape from globose-urceolate to tubular-campanulate; occasionally it is relatively open. In all species the flower is pendulous, and the pollen-presentation area usually lies within the mouth of the corolla, an arrangement which is secured mainly by the varying length of the antherine awns, at the tips of which the pores develop. Rarely are the awns carried beyond the mouth of the corolla, as in *V. japonicum*, Miq. and *V. urceolatum*, Hemsl.

Spur-like outgrowths of the stamen are not uncommon, their exact point of origin varying as described already for *Pieris*, but, as in that genus, they arise either from the free filament or from the connective. Certain general relationships may be gathered from figs. 47 and 48, i–xi, which refer to *V. Myrtillus*, Linn. The filament is attached dorsally, and traced upwards its margins are seen to persist as conspicuous ridges on the back of the anther (fig. 48, i–iv). Before the lobes diverge the ridges expand and bear the spinous outgrowths which form the spreading spurs of the stamen (fig. 48, v–vii). Where the lobes separate the two dorsal pollen sacs have disappeared, but those on the ventral side are carried a little higher. Beyond this point (fig. 48, viii–xi) the upper half of the anther is composed of those two tubular structures or awns which provide for the escape of pollen.

In *V. Dunalianum*, Wight (fig. 46) the dorsal ridges of the connective are specially prominent both above and below the

insertion of the spreading appendages. In *V. Kachinense*, Brandis, the general morphology of the stamen is similar to that of *V. Myrtilus*, Linn., but the spurs are carried farther forward, being borne on the dorsal ridges beyond the point where the anther lobes diverge. In fact, in the genus *Vaccinium*, as in *Pieris*, a progressive series can be traced showing a gradual shifting forwards in the position of the staminal spurs. It is of interest that where the spurs are very small or altogether absent, as in *V. Carlesii*, Dunn and *V. Henryi*,



FIGS. 46-48.—*Vaccinium* spp. Fig. 46, *V. Dunalianum*, dorsal view of anther ($\times 10$); fig. 47, *V. Myrtilus*, dorsal view of anther ($\times 12$); fig. 48, transverse sections of anther of same, numbered from base to apex, sclerenchymatous band dotted in components ix-xi ($\times 25$).

Hemsl., the corolla is seen to be relatively open. They are absent also in *V. Vitis Idaea*, Linn., *V. corymbosum*, Linn., *V. salweenense*, W. W. Sm., and *V. scopulorum*, W. W. Sm., where the corolla is more or less ampullaceous. Nor do they occur on the much exserted stamens of *V. japonicum*, Miq. The probable significance of such relationships will be discussed under *Erica*, where a larger number of species has been examined in this connection.

Dehiscence of the anther in *Vaccinium* is effected by means of pores which arise at the ends of the awns. In the young anther the awns are cellular throughout, but as growth pro-

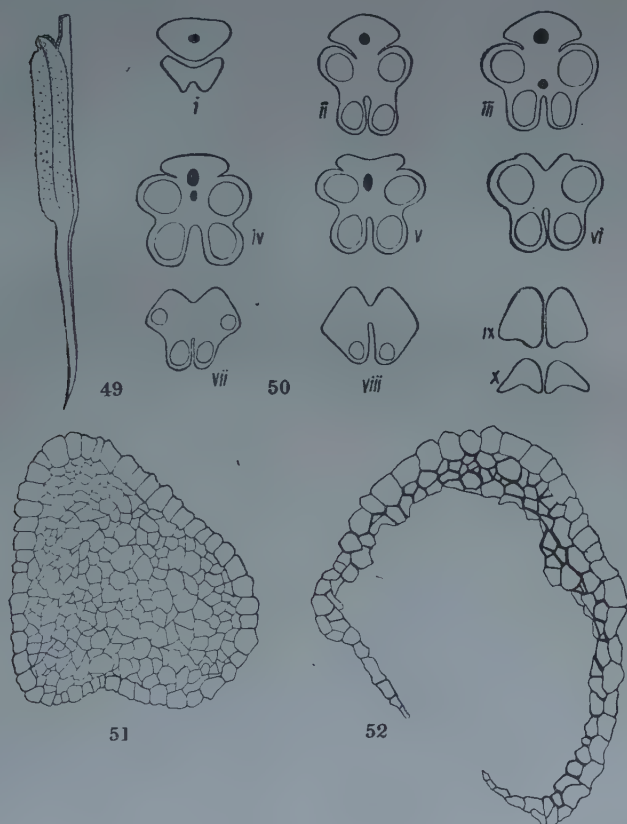
ceeds, disintegration of the thin-walled tissue begins on the inner face of each in the region where the opening will develop. This initiates the concavity, which gradually deepens to form the pore (fig. 48, xi). The opening is limited dorsally by a sclerenchymatous development of the hypodermis, which forms a crescent-shaped layer of cells as seen in transverse section. The destruction of tissue proceeds inwards and downwards, and finally the awns become those two tubular structures which connect with the pollen sacs below (fig. 48, ix and x). Although only the lower part of the anther is sporogenous, the pollen is presented at a level approximately that of the mouth of the corolla tube. There is no mechanical layer in any part of the anther wall, and the cells of the epidermis surrounding the microsporangia are conspicuously thickened on the outer walls.

PENTAPTERYGIUM.—Of this genus we have examined one species, *P. serpens*, Klotzsch. The plant bears pendulous flowers, the fleshy, tubular corolla varying from 2–3 cm. long. The stamens are slightly coherent, forming a close cylinder round the style, their tips projecting slightly beyond the corolla as a pointed cone. The lower half of each stamen is fertile; the upper part comprises two contiguous prolongations of the anther lobes forming an awn, at the extremity of which dehiscence takes place by means of vertical slits (figs. 49 and 50, i–x). The stamen is not calcarate. The anther is provided with a single vascular strand in the form of a hook which does not extend beyond the middle of the fertile portion (fig. 50, i–v).

In the young anther the slender prolongations of the lobes are formed of thin-walled parenchyma delimited by an epidermis composed of larger cells (fig. 51). As the anther matures, the central tissue breaks down and the structure becomes tubular throughout its length, thus forming a channel which connects with the pollen sacs. In the region of the apical slit the disintegration of tissue begins on the ventral side where a slight depression occurs (fig. 51) and a portion of the epidermis is here involved, but dorsally the process of dissolution seems to be inhibited by the lignification of two or three layers of hypodermal cells (fig. 52).

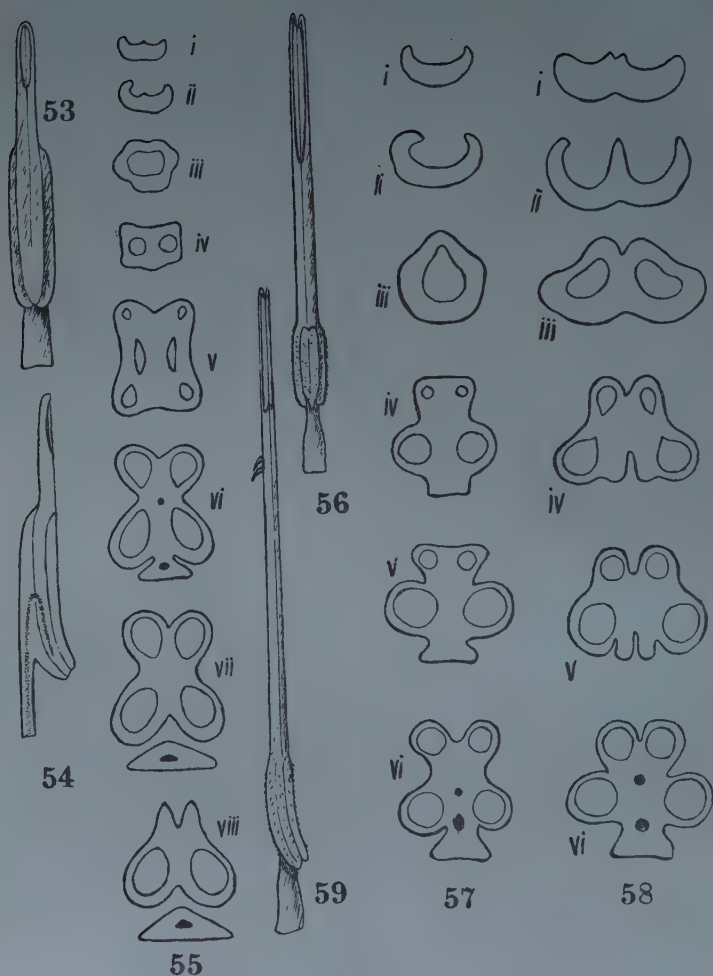
Neither in *Vaccinium* nor in *Pentapterygium* have we observed anything comparable to the resorption tissue which

is associated with pore formation in the genera already described, and Artopoeus refers to its absence from *Vaccinium*. It is probable that enzyme action causes the disintegration of tissue which leads to the formation of the apical



FIGS. 49-52.—*Pentapterygium serpens*. Fig. 49, side view of anther ($\times 2\frac{1}{2}$); fig. 50, i-x, series of transverse sections from base to apex ($\times 30$); fig. 51, transverse section of one of the terminal prolongations cut at level of slit, early stage before dehiscence ($\times 185$); fig. 52, later stage of same, after dehiscence ($\times 185$).

slit and the hollowing out of the antherine awns. If so, an interesting comparison may be drawn with the development of the pollen chamber in the apical part of the long, beaked nucellus in *Bowenia* described recently by Lawson (1926), who suggests that the chamber is formed by the action of



FIGS. 53-55.—*Macleania punctata*. Fig. 53, face view of stamen (\times circa 4); fig. 54, vertical section showing course of vascular strand (\times circa 4); fig. 55, i-viii, series of transverse sections of stamen numbered from apex to base (\times 22).

FIGS. 56-58.—*Agapetes buxifolia*. Fig. 56, face view of outer stamen (\times 3); figs. 57, i-vi and 58, i-vi, transverse sections numbered from apex to base of inner and outer stamen respectively (\times 22).

FIG. 59.—*Agapetes burmanica*, side view of stamen showing greatly elongated awn and the two small spurs ($\times 1\frac{1}{2}$).

enzymes. There is, at all events, no structural feature in the anther of *Vaccinium* or of *Pentapterygium* to suggest a dehiscence mechanism. All trace of a fibrous layer is lost, and in both genera there is a marked deviation from the ordinary angiospermic type of stamen.

MACLEANIA PUNCTATA, Hook. f.—The stamens are enclosed within the tubular corolla and fit closely together to form a cylinder round the style. The anther is adnate, fertile in the lower two-thirds, while the upper part forms a pointed, tubular structure which opens by an elliptical pore on its inner side (fig. 53). As in *Pentapterygium*, the vascular strand lies embedded in the tissue of the connective, forming a hook in the lower half of the fertile portion of the anther (fig. 54).

The beak-like prolongation of the anther constitutes a pollen presentation device. It is solid when young, but with the ripening of the anther it becomes hollow owing to disintegration of the thin-walled parenchyma in the centre. In the upper part of the beak below the pore, there is a single hollow cylinder (fig. 55, iii); at a lower level, where the tissue of the connective persists, there are two such cylinders (fig. 55, iv-v). Each is a channel connecting with the pollen sacs in the anther lobes below.

AGAPETES BUXIFOLIA, Nutt.—The stamens are about 2 cm. long and are slightly exserted beyond the mouth of the elongate corolla. The members of the inner whorl are somewhat slender and are compressed between those of the outer ring. The anther is adnate to a short filament, and only about one-fifth of its length is sporogenous (fig. 56). The awn is correspondingly long, forming a distal tubular prolongation for the shedding of pollen. In *A. buxifolia*, Nutt. the stamen is without spurs, but in certain species, as in *A. burmanica*, W. E. Evans (fig. 59), they are present as two small outgrowths of the dorsal side of the awn. They arise from the tissue of the connective, and their occurrence here, far removed from the filament, serves to emphasise the point already discussed under *Pieris* and *Vaccinium*, that the bristle-like outgrowths of the stamen in the Ericaceae are simply emergences, liable to occur on the filament or on the connective, and cannot be employed as a character of generic importance.

As in *Macleania*, the vascular strand supplying the anther in

Agapetes forms a small hook in the basal region of the fertile area (figs. 57, vi and 58, vi).

Dehiscence is effected by means of a long apical fissure (fig. 56), and, as in other genera of the Vaccinoideae, the removal of pollen in the pendulous flower depends upon a connection being established between the distal opening and the fertile lobes at the base. The condition described for *Macleania punctata*, Hook. f. holds for *Agapetes buxifolia*, Nutt., but in the latter an interesting structural difference exists between the inner and outer stamens. This is indicated in figs. 57 and 58. The channel which leads from the pollen sacs to the apical slit in the inner stamen (fig. 57) is single, but in the stouter stamen of the outer whorl (fig. 58) the anther lobes are resolved into a two-chambered prolongation, and each lobe dehisces introrsely by an independent slit, a portion of the connective persisting between the openings (fig. 58, ii).

The breaking down of the tissue of the awns to form tubes is probably due to the action of enzymes. The tissue of the awn is composed of small, thin-walled parenchymatous cells, and only the epidermal layer is thickened. It is the delicate central tissue which undergoes disintegration, but there is no evidence of resorption, nor is there any mechanical rupture. In these features *Agapetes* and *Macleania* are similar to *Vaccinium* and *Pentapterygium*.

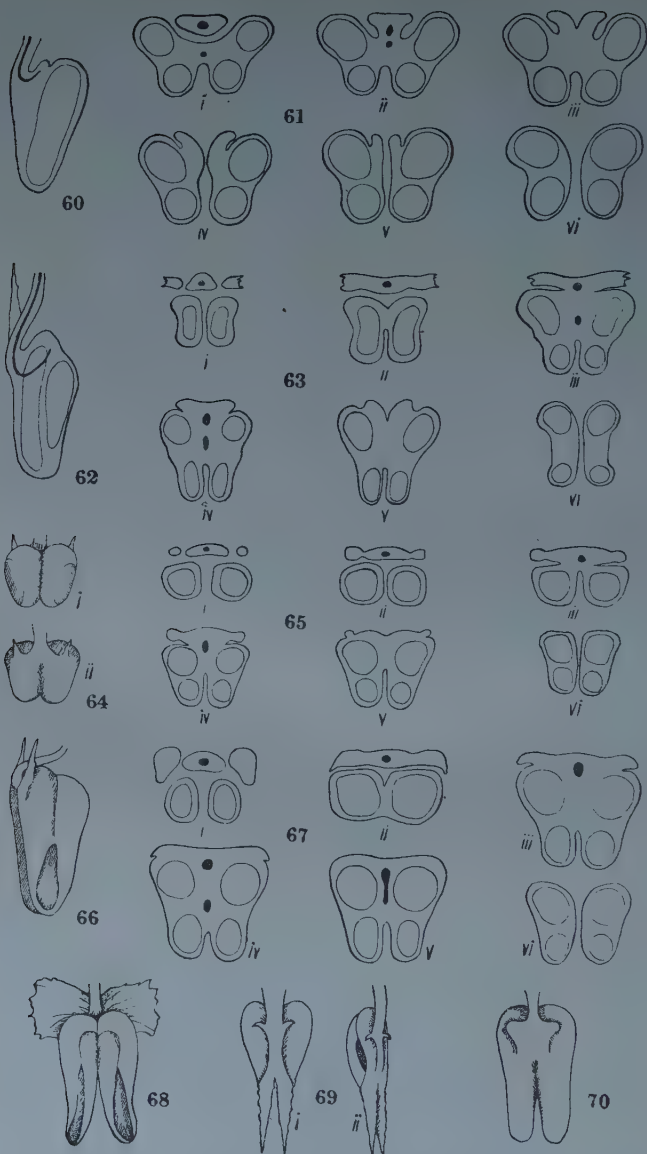
ERICOIDEAE.

This group is almost as numerous in genera as the other sub-families, but by far the largest genus is *Erica* and the only one we have examined in detail.

ERICA.—Considerable variety in floral morphology may be expected in a genus which includes about 500 species. Figures which give a good idea in the range of flower form are given by Drude. The corolla is frequently relatively narrow, tubular, tubular-urceolate, or ampullaceous; or it may be relatively broad, ovate, ovoid-urceolate, campanulate, or obconical. In the campanulate and obconical forms a condition approaching polypetaly is not infrequent, as in *E. canaliculata*, Andr., *E. capitata*, Linn., *E. Chamissonis*, Klotzsch, *E. crassifolia*, Andr., and others. These facts seem to have some bearing in relation to the general form of the androecium.

The bases of the filaments of the eight stamens often form a close cylinder round the ovary, and the anthers are frequently placed in a compact conical group round the style, an arrangement which provides a certain degree of rigidity to the androecium as a whole. Spur-like appendages to the stamens are frequent, but they are by no means a constant feature of the genus. They have often been regarded as balancing structures or as levers forming a trigger mechanism in pollination. To ascertain whether any relationships may exist between the presence or absence of appendages and the general morphology of the flower as a whole, we have examined 296 species. Of this number, appendages were noted in 185. Where the filaments are long and the anthers definitely exerted beyond the mouth of the corolla, appendages are always absent and the anthers are aggregated in a group round the style. This condition was found in 40 of those 111 species observed to have no spurs. It is seen in *E. vagans*, Linn. and *E. mediterranea*, Linn. among British species, and is a well-marked feature in *E. carnea*, Linn., *E. grandiflora*, Linn., *E. lineata*, Benth., *E. Plukenetii*, Linn., *E. racemosa*, Thunb., *E. Sebana*, Donn, *E. socciflora*, Salisb., and others. But in the majority of species the whole stamen hangs within the corolla, and appendages are then generally present, spreading outwards in a more or less horizontal position. In those forms with included but spurless stamens, the filament often shows a strong curvature and the antherine body then hangs in a balanced position, the curved part of the filament frequently resting against the wall of the corolla tube, especially where this is narrow or ampullaceous. Again, where the corolla is open with spreading lobes, the stamens are commonly short and unappendaged, and cluster round the ovary to form a rigid cone. The most variable condition is seen in those species where the stamens more or less equal the corolla tube. The stamens may then show appendages or not.

If the particular setting of the androecium in the flower of *Erica* confers any mechanical advantage where epipetaly is lacking—and this seems probable—it will aid also in the general mechanism of pollination. The cone-like aggregation of the anthers in those forms having exerted stamens, where normal longitudinal dehiscence is modified to apical slit dehiscence, recalls a similar sprinkling apparatus in such a



FIGS. 60-70.—*Erica* spp. showing various forms of anther. Figs. 60 and 61, *E. vagans* ($\times 58$); figs. 62 and 63, *E. Veitchii* ($\times 15$ and 30 respectively); figs. 64 and 65, *E. cyathiformis* ($\times 15$ and 30 respectively); figs. 66 and 67, *E. arborea* ($\times 30$ and 58 respectively); fig. 68, *E. glauca* ($\times 6$); fig. 69, *E. seriphifolia* ($\times 10$); fig. 70, *E. buccinaeformis* ($\times 5$). For further description see text.

pendulous flower as *Galanthus*. Moreover, the possibility of wind pollination cannot be entirely excluded. But where well-developed appendages are present on stamens which are enclosed within the corolla, a trigger mechanism is obtained. The two types have been described fully by Church (1908) for *E. carnea*, Linn. and *E. cinerea*, Linn., to whose account and to the description of other forms by Müller (1883) and Knuth (1909) reference may be made.

The appendages show considerable variation in size and form. Commonly they are long-pointed muricate structures, their roughness being due to sharp projecting cells of the epidermis (figs. 62 and 66). In *E. cyathiformis*, Salisb. (fig. 64, i and ii) and in *E. seriphiifolia*, Salisb. (fig. 69, i and ii) the processes are short and pointed, while in *E. buccinaeformis*, Salisb. (fig. 70) they appear as rounded protuberances. On the other hand, they may develop as broad, fan-like outgrowths, as in *E. glauca*, Andr. (fig. 68), spreading laterally beyond the anther lobes. There seems to be no relation between the size or form of the appendage and the size of the anther.

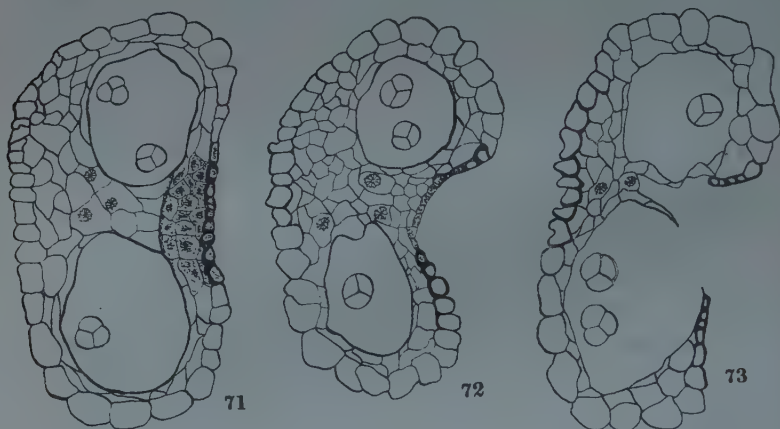
In the majority of species the point of origin of the appendage can be determined only by anatomical examination. In some species the outgrowths are clearly filamentous, but more generally they appear antherine (figs. 64 and 66), and as such they are usually described. Eighteen species have been investigated, and in all cases the outgrowths arise from the filament, often near its apex, or from the broad connective of the anther. Figs. 63, 65, and 67 are drawings of transverse sections which show the relationship between the appendages and the rest of the stamen in *E. Veitchii*, Hort., *E. cyathiformis*, Salisb., and *E. arborea*, Linn., respectively.

An interesting modification is seen in *E. seriphiifolia*, Salisb. (fig. 69, i and ii), and *E. cubica*, Linn. is similar. The appendages are small, spur-like outgrowths from the filament, while the anther lobes are prolonged distally as stiff, pointed beaks or awns. These are sterile and may be regarded as true antherine processes. Comparison may be made with the Vaccinoideae and with *Pieris bracteata*, W. W. Sm., where projecting awns are present on the anthers as pollen-delivering tubes. In *E. seriphiifolia*, however, the awns are solid and the pores develop laterally (fig. 69, ii).

In *Erica*, as in most genera of the family, the anther is pro-

vided with a single vascular strand in the form of a hook. In *E. vagans*, Linn., where the thecae are strongly divergent, the vascular hook is small (fig. 60), but in many species the hook is larger, as in *E. Veitchii*, Hort. (fig. 62).

Dehiscence of the anther is effected without the intervention of a typical fibrous layer. The peculiarity is referred to by Goebel (1905), who states that the epidermis probably plays a subsidiary rôle as a mechanical layer. This seems to be the case for *E. vagans*, Linn., which has been selected for drawing and description. The development of the opening in the



FIGS. 71-73.—*Erica vagans*. Fig. 71, transverse section through lobe of anther below the pore level showing on one side thickened epidermal cells and resorption tissue dotted ($\times 205$); fig. 72, transverse section of lobe through the region of the pore, before dehiscence ($\times 205$); fig. 73, transverse section through pore after dehiscence ($\times 205$).

anther wall is due primarily to the destruction of the epidermis and the underlying tissue in the region where the pore will appear. A transverse section of a single lobe of the anther before dehiscence has commenced is shown in fig. 72. The pore arises on the concave side, its position being marked by a number of small epidermal cells having dense contents. Surrounding the area of the pore is a rim of indurated cells belonging to the epidermis. It is this thickened rim which defines the pore and limits its extent. It is seen again in fig. 71, which represents a transverse section below the level of the pore. The rest of the epidermis is composed of larger cells having thinner walls, but as the anther ripens, several cells

on the dorsal side undergo thickening on the inner tangential and radial walls (fig. 73). As desiccation proceeds, the drying up of these cells and the collapse of their thin outer walls will tend towards a separation of the valves of the anther. Yet the formation of the pore itself depends upon the disintegration of a specialised tissue. This is the resorption tissue. It is restricted to the epidermis in the region of the pore (fig. 72), but lower down it extends further inwards (fig. 71). The epidermal cells are first destroyed, but the process gradually involves the partition between the pollen sacs, and the cavity thus formed is an irregular rather than a definite structure (fig. 73). Only externally is the pore more sharply defined by the border of thickened epidermal cells. As in certain genera previously described where resorption tissue occurs, the anther of *Erica* shows abundant crystals of calcium oxalate in its tissues, and the dissolution of the cell walls which takes place during anthesis is probably due to the action of oxalic acid.

DISCUSSION AND GENERAL SUMMARY.

The staminal apparatus throughout the Ericaceae may be held to be a specialised one, and would appear to be in advance of those other features in floral morphology which are the accepted criteria for placing the family at the beginning of a series of sympetalous dicotyledons. Presentation of pollen may be regarded as the main problem with which the mature androecium is concerned, and in most genera this is effected at or near the mouth of the corolla tube by means of apical pores or slits. Only in the Rhododendroideae does the wide, spreading type of corolla occur as a general feature, and in this subfamily the typical stamen with normal longitudinal dehiscence might be looked for. It is seen in *Ellittia*, *Cladotamnus*, and *Loiseleuria*, which are relatively primitive members of the group, and, as shown by Artopoeus for *Loiseleuria*, the epidermis functions as a mechanical layer. In *Kalmia*, *Phyllodoce*, and *Daboecia*, which we have examined especially, the vertical slit is restricted to the upper part of the anther wall, and in *Phyllodoce* a well-marked hypodermal fibrous layer is developed in the region of the opening. In *Kalmia* the hypodermis is thickened, but typical fibrous cells

are confined to the epidermis, while in *Daboecia* only the epidermis may function mechanically. It is, therefore, necessary to modify Chatin's statement regarding the Ericaceae that cells of the second layer of the anther wall never show fibrous thickenings, and to emphasise the observation of Leclerc du Sablon that each particular case requires special examination. In this connection it is of interest to note that in *Clethra* a characteristic endothecium is found, and in the Epacridaceae, with longitudinal dehiscence of the anther, a greatly thickened exothecium is figured by Artopoeus for *Styphelia lanceolata*, Sm. and by Brough (1924) for *S. longifolia* (R. Br.). We have noted a similar thickening of the epidermal layer in *Epacris impressa*, Labill. and *E. rosea*, Lodd.

In the Rhododendroideae, therefore, there is evidence of a gradual loss of a typical hypodermal fibrous layer or endothecium, and its replacement by an exothecium which, however, seldom shows fibrous thickenings of its cells. This modification in the structure of the anther wall appears to be related to the tendency towards apical dehiscence, and the development appears to have followed different lines. In *Rhododendron* itself, which retains an open flower structure, the stamens curve upwards and the anthers exhibit true porose dehiscence, involving a shrinkage of the partitions between the pollen sacs. But the pollen tetrads do not fall out; they are drawn out by means of viscid threads. On the other hand, in *Phyllodoce* and in *Daboecia*, which belong to the same subfamily, the flower becomes more pendulous, and this habit, once adopted, remains dominant throughout the family as a whole. Dehiscence of the anther by means of apical slits will allow, therefore, of a gradual sprinkling process when the flowers are shaken either by wind or by insect visitors. But if the anthers are to liberate pollen at a level approximately that of the mouth of the corolla, the length of the stamen should bear some relation to the length of the corolla tube. The stamens may be more or less exserted, but generally they are included and the anthers are protected within the throat of the corolla. The actual adjustment may be attained by varying the length of the anther itself or the length of the filament. In the Rhododendroideae the filament is relatively long, but an exception to this is seen in *Daboecia*,

which has a long anther wholly sporogenous. Again, in the *Arbutoideae* and *Ericoideae* the filament is well developed, but in the *Vaccinoideae*, especially those forms with long tubular corollas, such as *Pentapterygium*, *Agapetes*, and *Macleania*, the filament is short and the anther remarkably long. The production of a much-elongated anther, however, were it to remain wholly fertile, would result in a heavy physiological drain, and economy is exercised by limiting the spore-producing part to the base of the anther. The distal sterile portion is then resolved into tubular structures opening at the summit, forming a channel for the discharge of pollen at the right place. In *Vaccinium* there are two such prolongations, one to each anther lobe, and they tend to diverge. But in *Pentapterygium* they are contiguous, and in *Agapetes* and *Macleania* they are united. These apical prolongations of the anther in the *Vaccinoideae* express the tendency to economy of pollen in a floral type which shows in its epigyny a considerable advance beyond the prevailing flower structure of the *Ericaceae* as a whole, and it is of interest that in the *Compositae* with a high degree of specialisation in the mechanism for pollination there is a similar tendency to limit the sporogenous tissue by the development of both apical and basal appendages to the anther (Small, 1915).

The distal prolongations of the anther lobes which occur in the *Vaccinoideae* may be described as awns, and have to be distinguished from the bristle-like appendages which are found in the *Arbutoideae* and *Ericoideae*. These staminal outgrowths we have spoken of as spurs, although they have been described under various names in works on flower biology. Their frequent occurrence in many genera where the stamens are included within the corolla has suggested to numerous observers a useful purpose in relation to insect pollination. They are never present in the *Rhododendroideae*, and in the large genus *Erica* they are absent in all species where the stamens are exserted. Within the limits of a single genus the spurs have been variously described as filamentous or as antherine, and the distinction thus apparently offered has been claimed to possess taxonomic value. But we have shown that in *Pieris*, *Vaccinium*, and *Erica* the spurs may originate either from the filament or from the connective, and since these structures are morphologically inseparable the

spurs themselves must be held simply as outgrowths from a microsporophyll. Their actual position on the stamen does not afford a taxonomic character of generic value as claimed by Rehder.

In certain members of the Arbutoideae the appendaged stamens show an interesting condition which may be regarded as intermediate between the ericoid type with spurs and the vaccinoïd type with awns. The claw-like processes which terminate the anther lobes in *Gaultheria* are prolongations of a peculiar form of connective, and the pores occupy a position at the base of these. In *Arbutus* and *Arctostaphylos* also, the slender appendages terminate the lobes of the anther, but they do not, as in the Vaccinoideae, take any part in the presentation of pollen, for the pores occur in the anther wall near the base of the appendages. In *Pieris bracteata*, W. W. Sm., however, the vaccinoïd type is foreshadowed, for this species is provided both with terminal tubular awns and dorsal spur-like outgrowths.

Although there is manifold variety in the general external morphology of the ericoid stamen, there is less variation in anatomical structure and in the method of dehiscence. The inversion which the anther undergoes during its development, described by Artopoeus (1903) and by Matthews and Taylor (1926), is reflected in the course of the vascular strand which supplies it. This has been figured for a number of examples as a curved vascular hook embedded in the tissue of the connective, an arrangement which seems to be general except in *Arbutus* and *Arctostaphylos*. The end of the strand is directed towards the apparent base of the anther, but this lower extremity is, in fact, the organic apex of the structure, and the so-called apical pores are really basal. In general, the lower part of the anther only is provided with vascular tissue, and the hook is especially small in those forms, such as species of *Erica*, where the anther lobes are separate almost to the base. In *Daboecia* an ascending branch passes from the main supply into the upper part of the long anther which is fertile almost to the apex, and in *Vaccinium*, where the anthers are also long, there are indications of this ascending strand. It might have been expected as an anatomical feature of all the Vaccinoideae, but, if ever present, its suppression would follow naturally on the sterilisation of the distal portion of the

anther. In *Arbutus* and *Arctostaphylos* the anther remains erect during the early stages of development. But the anther is here hinged to the filament, and gradually assumes an inverted position as the flower expands.

The apical pores or fissures appear as the result of disintegration of tissue which is laid down early in development in the wall of the anther. This specialised tissue in the pore area is often characterised by the smallness of the cells of which it is composed and by the density of their contents. It has been described by Artopoeus as resorption tissue, and its disappearance during the early phases of anthesis is referred by that author to the action of enzymes. The presence of calcium oxalate in several of the examples we have examined, belonging to the *Rhododendroideae*, *Arbutoideae*, and *Ericoideae*, suggests that oxalic acid may aid in the dissolution of the cell walls, as described by Namakawa (1919), as one of the methods of anthesis in some species of *Solanaceae*. In the *Vaccinoideae*, however, resorption tissue does not occur, nor have we observed crystals of calcium oxalate.

The pore cavity may be defined by an indurated rim of cells belonging to the epidermis. This is well seen in *Rhododendron*, where true porose dehiscence occurs, but a more general feature is dehiscence by means of an apical fissure and, excluding the *Vaccinoideae*, the epidermal or hypodermal layer of the anther wall in the region of the slit becomes modified to function mechanically subsequent to the initiation of the pore itself. Among the genera investigated, *Phyllodoce* alone retains a fibrous layer in the pore area, and, as already stated, there appears to have been a gradual loss of a characteristic endothecium in relation to the tendency towards apical dehiscence. This loss is to some extent compensated by a development of the exothecium, but even this feature is suppressed in the more highly evolved *Vaccinoideae*.

The specialisation of the stamen in the *Ericaceae* thus appears to have followed different lines. In the genus *Rhododendron* terminal pores have been elaborated, involving in their establishment a peculiar behaviour of the tissue forming the partitions between the pollen sacs. Whether the tendency towards apical dehiscence preceded the general assumption of the pendulous flower habit it is impossible to say, but it is suggested that within the limits of the family the occurrence

of these two features is not unconnected. The prevalence of spreading spurs on the stamens, sufficiently characteristic to suggest the name *Bicornes* for the family, may also be associated with the pendulous nature of the flower, giving a certain mechanical advantage in relation to pollination in the complete absence of epipetaly.

Close comparisons may be drawn in the general structural features of the stamen, as seen in many of the *Rhododendroideae*, *Arbutoideae*, and *Ericoideae*, but in the *Vaccinoideae* a greater degree of specialisation is reached. This is interesting in view of the advance to epigyny shown by this subfamily, but whether the differences are sufficient to warrant the recognition of the group as a distinct family must remain largely a matter of opinion. Although the vaccinoid type of stamen is foreshadowed in genera belonging to other groups, a consideration of the evidence inclines us to the view that the *Vaccinoideae* should be given family rank. In this we differ from Drude, but agree with Bentham and Hooker.

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HARD SEEDS AND BROKEN SEEDLINGS IN RED CLOVER
(*Trifolium pratense*). II. STORAGE PROBLEMS.

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(Read 20th May 1926.)

As is well known, there commonly occur seeds which, when offered ideal conditions for germination, fail to absorb moisture and therefore remain dormant and hard. These so-called hard seeds are typical of the *Leguminosae*, and usually germinate promptly if the testa be scratched or abraded. In practice, when a consignment is known to contain a high percentage of hard seeds, it is passed through various machines specially designed to cause abrasion in varying degree.

Many seeds in samples of clover, particularly Red Clover, produce, during a germination test, plantlets which break, usually in the region of the hypocotyl. Increased severity of abrasion has been found to result in an increased percentage of these broken seedlings. In practice it is desired to reduce the hard seed content to the minimum while causing no increase in the broken seedlings: thus increasing the percentage of seed which may be declared viable under the regulations (5). Only this percentage is of primary value in commerce, and the short term "valuable seed" will be used for it hereunder.

Numerous observers have reported on the behaviour of seed and grain under storage, paying particular attention to the percentage of living seed, its decrease with age, and the point where the last of the seed becomes non-viable. In the case of the agricultural seeds, at least, this information is valuable only with regard to the second item, and then only for the first few years, because rarely is a consignment carried over for longer than eighteen months after harvest. Further, though information regarding the percentage of seed capable of germination is of prime importance, the behaviour of the other constituents may be only slightly less so. In the tests reported here full details will be given.

Materials and Methods.—A consignment of new Red Clover seed of crop 1924 was selected in December of that year and a sample reserved from the delivery; two further samples were obtained from two portions which were slightly and severely

abraded respectively. Each of these three samples was divided into four portions, giving twelve lots in all, and one from each group stored in each of the four following ways:—

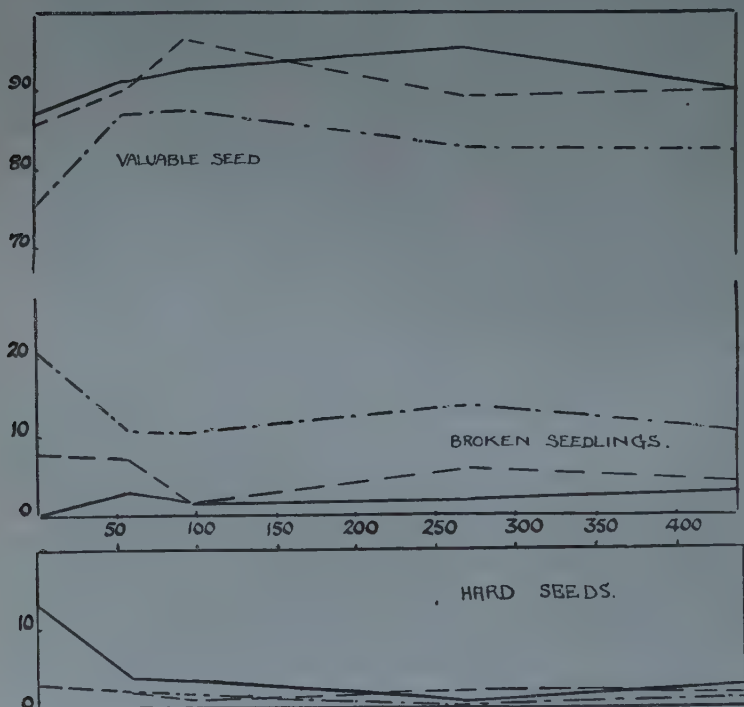
- (a) Over CaCl_2 in a desiccator (excessively dry conditions).
- (b) Over a solution of NaOH (moist conditions).
- (c) In glass tubes tightly packed with seed, the corks being sealed in and capped with beeswax (poorly ventilated conditions).
- (d) In glass tubes stoppered with cotton-wool (approximately normal conditions).

The aim in (a), (b), and (c) was to produce exaggerated conditions which might operate in practice with less intensity.

Both of the lots subjected to abrasion were machined on the same day, and forthwith all three samples were put to test, divided, and set to store; the results of this first test provides the starting-point of the graphs. In all cases in the figures the solid line — refers to the non-abraded seed, the broken line - - - - to the mildly abraded lot, while the chain line — · — · — refers to the severely abraded sample. The main figures (1-4) show the percentage of valuable seed (those germinating to produce normal seedlings), the broken seedlings, and the dead. Hard seeds are shown separately. As a measure of economy the vertical scale in some cases has been broken and only the significant portion of the graph shown. Time in days is plotted along the base; the percentage of the different constituents found, on the vertical scale.

Discussion and Conclusions.—A general examination of the graphs shows that the immediate effect of abrasion has been to increase the percentage of broken seedlings at the expense of the hard seeds and, what is very undesirable, at the expense of the valuable seed, thus reducing the commercial value of the consignment to below the pre-machining point. After storage under excessively dry and approximately dry conditions, the broken seedling curve dwindles away, the percentage being added to the valuable seed so that the commercial value of the consignment rises much above that of the unmachined seed. This would indicate that for best results the merchant should store seed for some fifty to one hundred days after abrasion. This, however, is not always convenient. Excluding the graph of moist storage, fig. 4, further examination shows that after

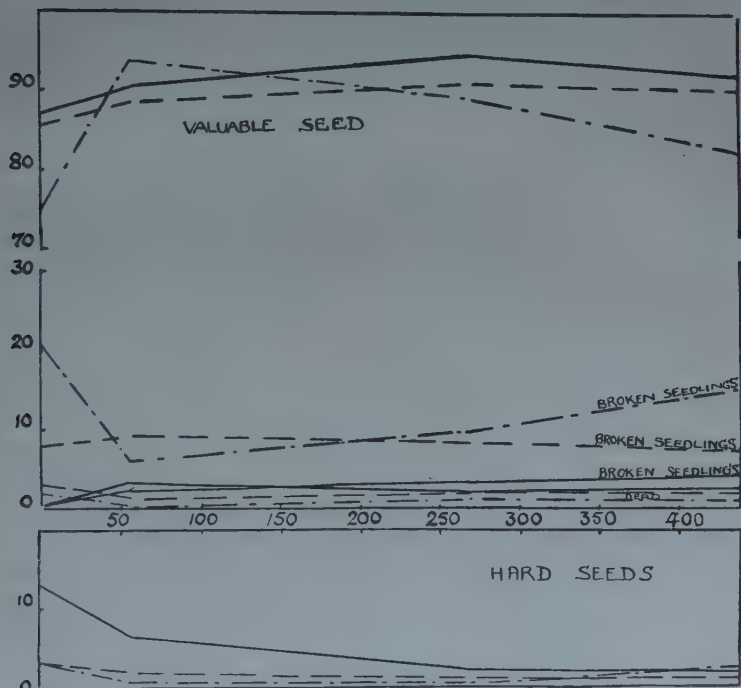
reaching a high point the curve of valuable seed commences to fall; the rapid decline being particularly noticeable in the case of the excessively dry stored lots. This loss is not due to a return of the broken seedlings, but to the seeds becoming dead. This is brought out clearly by the form taken by the curves of the total seed germinating (valuable seed plus broken seedlings), fig. 5.



FIGS. 1 and 1A.—Seed stored normally. (The dead negligible in every case and not shown.)

It is commonly believed that in a dry atmosphere the hard seed content increases; this is not clearly indicated in these tests, but it is interesting to note that in the case of the un-abraded seed under excessively dry conditions, the hard seed curve tends to rise towards the end of the period reviewed. Dorph-Petersen (2) records a case of a sample of Red Clover which, stored under slightly drier than normal conditions, dropped from 6 per cent. hard in its harvest year to 1 per cent.

in the fourth year, rising to 11 per cent. in the sixth year, this figure remaining constant until all the non-hard seeds had died ten years later. It is noteworthy that in the tests here recorded the least fall in hard seed content is found in the unabraded seed stored under very moist conditions. It is possible that these tests have not continued long enough for any reappearance of hard seeds to develop, but it probably is significant

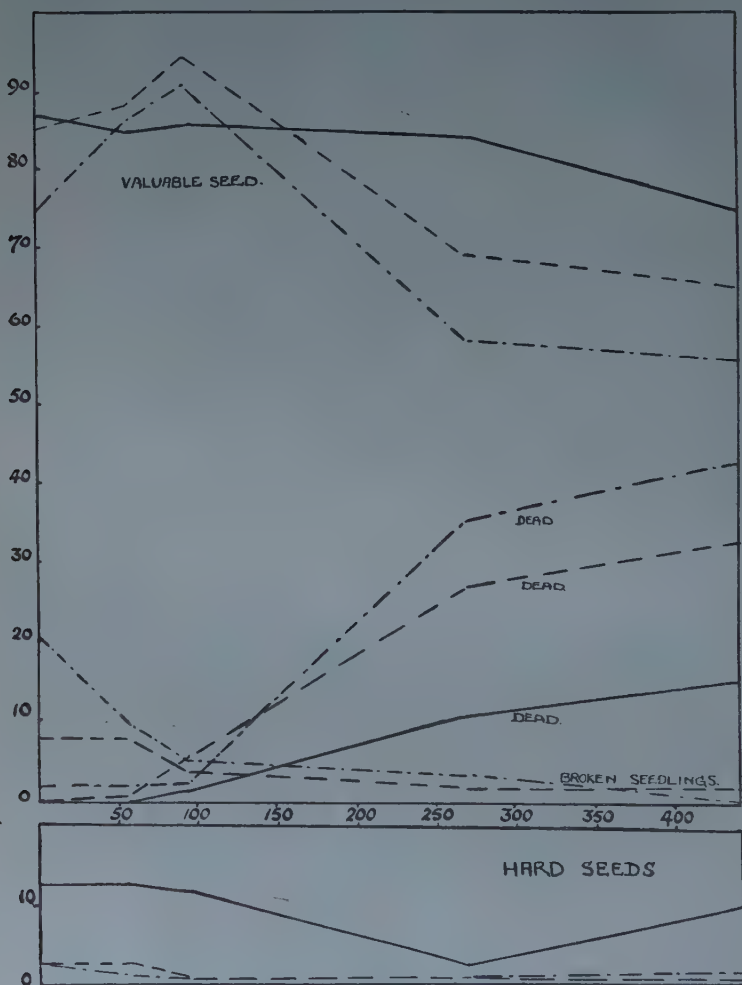


FIGS. 2 and 2A.—Storage in sealed tubes.

that no increase in hard seed content can be detected in any abraded lot.

Considering for the moment only figures 4 and 4a, which represent the results of storage under very moist conditions, it is to be noted that in the case of all three lots there is a sharp and immediate rise in the dead seed curve. This rise in dead seed, coupled with a slight rise in broken seedlings in the case of the non- and slightly abraded lots, results in a fall of the valuable seed curves. At a comparatively early date this rise

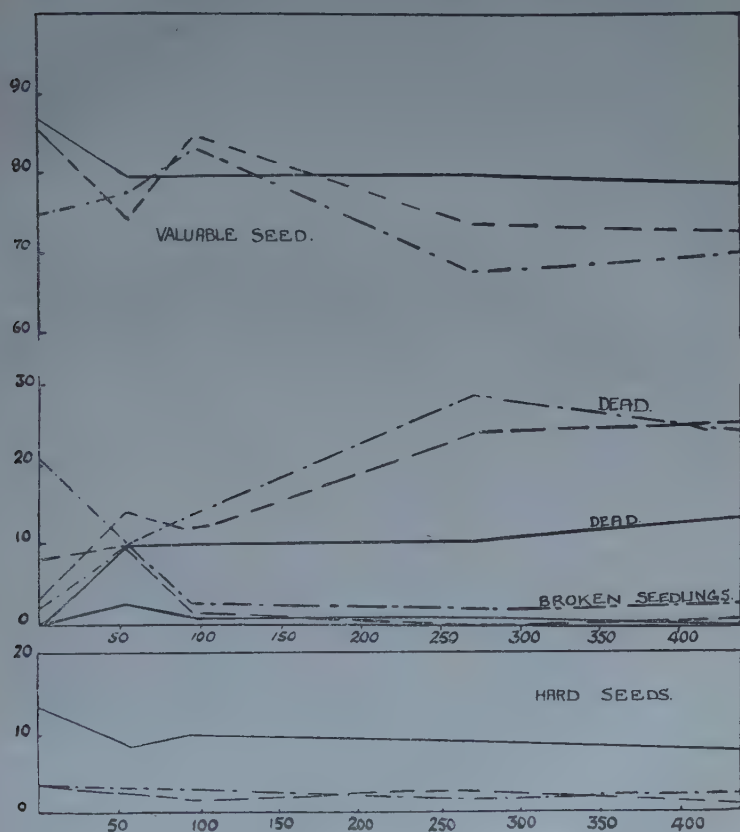
in dead seed ceases and the valuable seed curve flattens out, while a continued death-rate in the abraded lots brings all



FIGS. 3 and 3A.—Storage under excessively dry conditions. (Broken seedling of unabraded seed negligible and not shown.)

three curves into relative positions similar to that found for the other types of storage. Dealing still with moist storage only, fig. 5, which represents the total seed germinating, shows that the death-rate in the first fifty days or so for each

of the lots has been similar, irrespective of the machine treatment, the three curves being practically parallel. It would seem clear that there is some proportion of the seed in the sample peculiarly sensitive to the lethal effects of moist storage, and that these are not specially related (as with the lethal



FIGS. 4 and 4A.—Storage under moist conditions.

effects of dry storage) to the class producing broken seedlings. In this connection it is to be noted that Pearl and Allen (4) found that when samples of seed were steeped in solutions of ethyl alcohol for three hours the germination was depressed. This depression of germination was not proportional to the strength of the alcoholic solution, but was constant at 8 per cent. for all strengths of solution up to 8 per cent. of alcohol.

The subsequent growth of the seedlings from seed which had been steeped in the alcoholic solutions was very much more vigorous than that of seedlings from seeds steeped in water only. The authors conclude that the alcohol killed off the weak members of the sample, leaving only the strong and vigorous. It is suggested that the moist storage described here acted in a somewhat similar way, selecting out and killing those embryos deficient in vigour. This would seem to be the essential difference between moist and dry storage. Excessively dry storage acts particularly on the seeds with thinned coats, probably through more rapid denaturation of the embryo proteins—a cause of loss of germinating power suggested by Crocker (1). Wet storage, while allowing denaturation of the embryo proteins to go on, attacks particularly seeds containing embryos of low vitality—possibly those harvested in an immature state—and this by simple rotting. The samples in moist storage showed mould attack at an early date.

The reason why those seedlings which break when tested immediately after abrasion become normal after storage is obscure. It has been suggested [Nelson (3)] that a broken seedling results from a thinning down or weakening of the seed coat (as by excessive abrasion), with consequent derangement of the normal stresses and resistances to pressure offered by the testa to the swelling embryo. If storage resulted in either the repair of the seed coat or a weakening of the energy of the enclosed embryo, then a return to normality might be looked for. If the whole of the initial rise in the percentage of valuable seed in the abraded lots be due to the return to normality of the testa, then the later continuous fall is difficult to explain. When the thinned coats reach normality, the curve of valuable seed should flatten out and run parallel with that of the machined seed. If, however, it be accepted that the storage results in a progressive reduction in vigour of the embryos, the initial rise in the valuable seed curve is explained by the seeds which had produced broken seedlings reaching a point where internal pressure following loss of vigour becomes reduced to a value suited to the reduced strength of the testa. This would also explain the later continuous falling off in the valuable seed curve due to increase in the dead: a continuous process is postulated. Further, this view would explain the

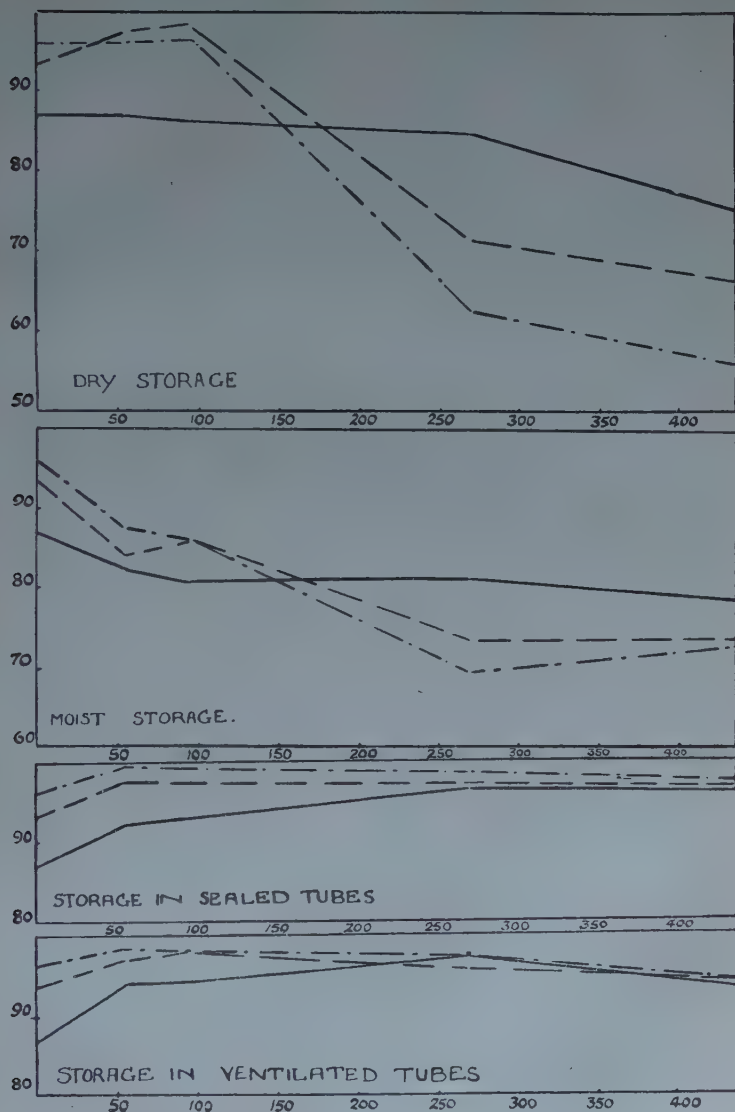


FIG. 5.—Total seed germinating. (Valuable seed plus broken seedlings.)

proportionality which obviously exists between the degree of abrasion and the fluctuations of the various constituents.

The tests were carried out in the Scientific Department of Messrs. David Bell Ltd., Leith.

SUMMARY.

1. As has been shown in the previous paper, a direct result of abrasion is the production of broken seedlings in amount proportional to the intensity of the abrasion.

2. Immediately on storage the percentage of broken seedlings declines with concurrent rise in the percentage of seeds which germinate normally.

3. Further storage results in a rapid loss in value of the abraded lots due to a rapid death-rate. This death-rate is proportional to the degree of abrasion.

4. The occurrence of broken seedlings is attributed to testa weakness, caused by abrasion, their subsequent disappearance and the following death-rate to continued loss of embryonical vigour, resulting in a return to a balance of internal pressure to seed-coat strength. All these fluctuations are proportional to the degree of abrasion.

5. Moist storage kills off a class of seed distinct in character from the abraded seed, probably those containing a weak or immature embryo.

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- (3) NELSON, A. (1924): Hard Seeds and broken Seedlings in Red Clover. Trans. and Proc. Bot. Soc. Edin., vol. xxix, pt. i.
- (4) PEARL, R., and ALLEN, A. (1926): The Influence of Alcohol upon the Growth of Seedlings. Journ. Gen. Phys., vol. viii, No. 3.
- (5) Board of Agric. for Scotland (1922): The Seeds (Scotland) Regulations made under the Seeds Act, 1920 (10 & 11 Geo. V. c. 54).

THE ORIGIN OF ADVENTITIOUS GROWTHS IN ACANTHUS MONTANUS. By GEORGE TAYLOR, B.Sc. (With Pls. XI-XII).

(Read 20th May 1926.)

In a paper published in Trans. Bot. Soc. Edin., xxviii (1922), Mr. L. B. Stewart has given an account of various adventitious shoots arising from cuttings of *Acanthus montanus*. The plant is remarkably plastic, for under suitable conditions new individuals may be obtained from severed portions of the root (either prop root or earth root), the stem (cut at node or internode), or from the leaf. Since the plant is so responsive to these various methods of vegetative propagation it was considered suitable material for an anatomical investigation of the precise origin of adventitious growths.

METHODS.

In growing the plants the following course was adopted: Cuttings were inserted in coconut fibre in a propagating frame having a mean temperature about 65° C. At suitable intervals appropriate stages in the development of adventitious growths were selected for microscopic examination. The material was killed and fixed in Carnoy's fluid, and afterwards heated in water up to 100° C. in order to remove the mucilage which is abundant in the tissues. Treatment with hot water for at least thirty minutes is necessary.

The ease with which *Acanthus montanus* can be propagated vegetatively is probably correlated with the presence of abundant food reserves in all the vegetative parts of the plant. Starch grains are plentiful in the cells of the cortex of the earth root, though they are found only sparingly in the green, aerial, or prop root. They are also abundant in the cortex and pith of the stem, and in the ground tissue of the petiole. As already stated, the tissues contain mucilage, and its removal is essential in order to obtain clear differential staining in microscopic preparations. The mucilage is fatty in character and gives the fat reaction with Sudan III and osmic acid. Crystals of calcium oxalate are also found sparingly throughout the tissues.

PROPAGATION FROM THE SOIL ROOT.

The young root shows normal structure. Starch is plentiful in the cortex. The stele is medullated, the pith serving, for some time at least, to store starch. In the older root the cells of the pith have undergone lignification and starch has almost entirely disappeared. At this stage secondary thickening has commenced.

Adventitious growths may appear from cuttings of the young root still showing primary structure, or they may arise from root cuttings in which secondary thickening has commenced. When the soil root is used as a cutting the first change observable at the basal cut end (*i.e.* towards the organic apex of the root) is the accumulation of a blocking substance in the vessels and on the walls of the ruptured cells. The presence of this blocking material is obvious three days after insertion of the cutting, though it becomes more conspicuous later. It is suggested that the blocking substance is an oxidation or coagulation product of the fatty mucilage. The upper end of the cutting shows a similar blocking, though not to such a marked extent. At this stage, after three days in soil, no cell division has taken place at either end of the cutting.

Anatomical study of the basal end of the root cutting, which has been in the propagating frame for three weeks, reveals the following changes: cell division has taken place—parallel to the cut surface—in the cells of the cortex, pericycle, and pith, the new tissue thus formed extending to a depth of two or three cells, and constituting a narrow zone of callus over the cut surface, with the exception of the xylem vessels. Cell division is most active in the pericycle, and it is here that root primordia are established, their apices being directed downwards. At the upper end a thin callus is formed, but the most obvious feature is the development of buds from the pericycle. A well defined apical meristem showing procambial strands is seen in fig. 1. A constant character, which readily distinguishes all adventitious buds from root primordia, is the presence of multicellular hairs arising on the epidermis (fig. 1).

PROPAGATION FROM THE PROP ROOT.

The anatomy of the prop root differs in several respects from that of the soil root. A large pith is present, round the

periphery of which are arranged xylem and phloem strands. Associated with the xylem are masses of lignified fibres more or less connected laterally. These give rigidity to the root. The pericycle consists of four or five layers of small, thin-walled cells, and is defined externally by the endodermis. The cortex of the prop root contains abundant mucilage, but starch is not present to any great extent, and the few isolated grains which occur are probably transitory products formed by photosynthetic activity of the root itself. Covering the prop root are numerous unicellular hairs (fig. 2).

The prop root cutting, one week old, sectioned longitudinally, shows only a slight accumulation of blocking substances at the cut ends. Cell division has taken place in the cortex and pith, but the pericycle at this stage shows little meristematic activity. Cell division is more active at the basal than at the apical end.

Sections made at either the upper or lower end of a cutting, two weeks old, show the formation of a callus derived from the cortex and pith. There is also a marked change in the pericycle, which appears as a broad zone of actively dividing cells. Near the basal end of the cutting a transverse section shows the initiation of roots from the pericycle. These roots appear as localised cones of small, deeply staining, meristematic cells, directed towards lysigenetic air spaces which arise in the cortex opposite the root primordia (fig. 2). The root gradually emerges by growth through the cortex.

At the upper end of the cutting, buds arise from the pericycle as in the soil root.

PROPAGATION FROM THE STEM.

The stem is square in outline and bears opposite and decussate leaves. In its anatomical construction it does not depart from the normal dicotyledonous type.

All stem cuttings were portions of the shoot severed in two places, that is, each portion of shoot employed had two cut ends which will be referred to as upper and lower. In some cases the severance was made at the nodes, thus giving a cutting of one or several internodal lengths, a node being present at each end. Others were cut to give internodal ends. Such cuttings may be made from young or woody stems and

successfully rooted, whether taken at the node or internode. Those which have been in the propagating pit for one week are effectively blocked at the cut ends. They show a thin zone of meristematic cells immediately underlying the cut surface at the upper end of a nodal cutting and at a depth of three or four cells from the cut surface at the lower end. In a cutting two weeks old this zone of callus is more pronounced, and meristems, consisting of small, actively dividing cells full of cytoplasm, have been initiated at the upper end. These meristems are derived from the cambium, and by continued growth emerge through the callus as adventitious buds (figs. 3 and 4). The callus simply acts, therefore, as a healing tissue and takes no part in the formation of bud meristems.

Usually numerous buds are formed in a ring over the cambium, but most of these remain dormant and only a few develop. In many cases one definite leader is formed, and if this becomes injured new shoots arise from the dormant buds.

After three weeks, roots emerge near the base of the stem cutting, usually in two rows. They develop from the cambium and make their way through the cortex in a horizontal direction, emerging about an eighth of an inch from the end of the cutting. The young root before emerging shows differentiation into root cap, periblem, and plerome.

PROPAGATION FROM THE LEAF.

A transverse section of the petiole shows a small pith, an almost complete cylinder of xylem, but no cambium. The continuous pericycle becomes the meristematic layer. In addition to the central cylinder, the petiole is provided with two accessory strands situated in the cortex towards the adaxial side. These smaller strands are continued alongside the main supply in the midrib of the lamina. The vascular skeleton of the lamina forms a reticulate system, and from some of its branches, in the region of the midrib, root initials may be formed. Mucilage is abundant in the tissues of the petiole, and starch is also present in the cortex and pith.

A leaf cutting, five days old, sectioned longitudinally through the petiole, shows that the conducting elements are blocked, and at this early stage root initials are already formed from the pericycle. No divisions parallel to the cut surface have been

observed at this stage. That the meristems which give rise to the root initials are pericyclic in origin is obvious in a transverse section, since the cells of the pericycle are seen to have undergone division. After seven days, one or several roots may have emerged from the cut end of the petiole. In the course of time a fibrous root system is established. It is not only the main vascular strand which gives rise to roots, but the smaller accessory bundles may also contribute to the formation of the adventitious root system. There is no definite regularity in the formation of roots from the several vascular strands in the petiole, for one or more may arise in connection with the central trace, or roots may develop only from the smaller strands, or both conditions may be present in one cutting.

The development of buds from the leaf cutting does not begin until the adventitious root system is well established. Meantime the cut end of the petiole has become healed by a large pad of callus which the roots traverse. This callus is proliferated mainly from those parts of the pericycle which have not been concerned in the production of adventitious roots, but its formation is supplemented to a small extent by division of cells belonging to the cortex and pith. The callus is defined externally by a layer of cork arising from a cork cambium which is derived from the callus itself. Within the callus pad there is differentiated a band of annular and spiral tracheides connecting with the vascular supply of the petiole. Starch is abundant in the cellular tissue of the callus.

The buds arise near the periphery of the callus immediately underneath the cork cambium, not from the cork cambium itself. Each bud primordium soon becomes connected to the vascular band in the callus pad by the formation of procambial strands which ultimately differentiate to form the vascular supply to the buds. Usually several buds develop from the callus, giving rise to shoots which exhibit very marked juvenile characters in the first formed leaves. All shoots arising from adventitious buds on the different form of cuttings described above show juvenility, marked by spineless and rather tender leaves in contrast to the hard, prickly leaves of the adult plant. But the degree of juvenility varies. It is most pronounced in the case of shoots derived from leaf cuttings.

CONCLUSION.

From the foregoing account it would appear that the initiation of adventitious growths in *Acanthus montanus* is not restricted to one tissue. In the case of the stem and the root cutting, buds arise from the cambium or pericycle, but in the leaf cutting they originate from callus. Roots are always formed endogenously from the pericycle in the root and in the leaf cutting, but in the stem cutting they arise from cambial tissue.

DESCRIPTION OF PLATES.

- Fig. 1. Longitudinal section of upper end of soil root cutting, showing adventitious bud derived from pericycle.
- Fig. 2. Transverse section of prop root, showing initiation of adventitious root opposite air spaces which have appeared in the cortex.
- Figs. 3, 4. Longitudinal sections of upper end of stem cuttings, showing later stages in development of adventitious buds.

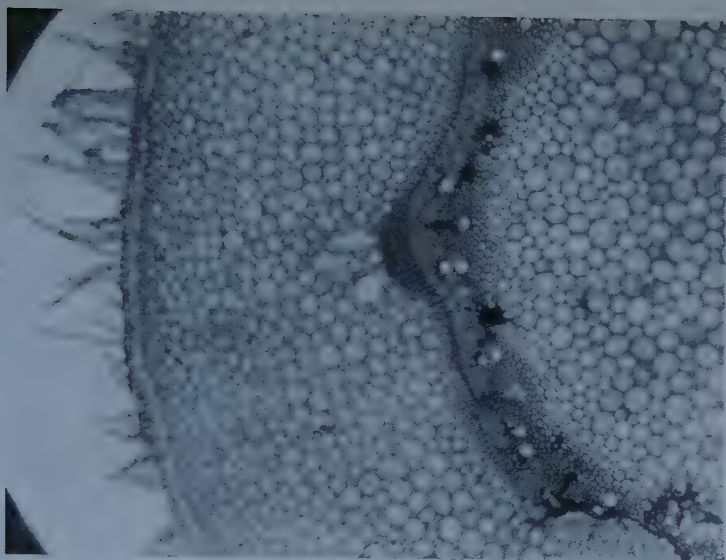


FIG. 2.

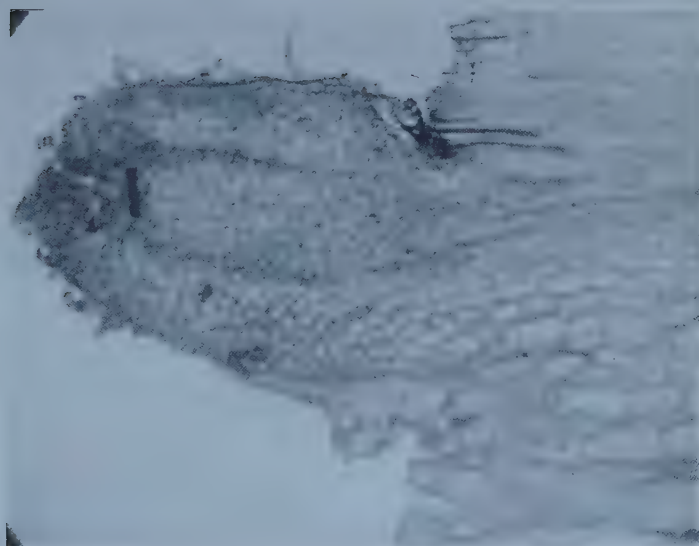


FIG. 1.



FIG. 4.

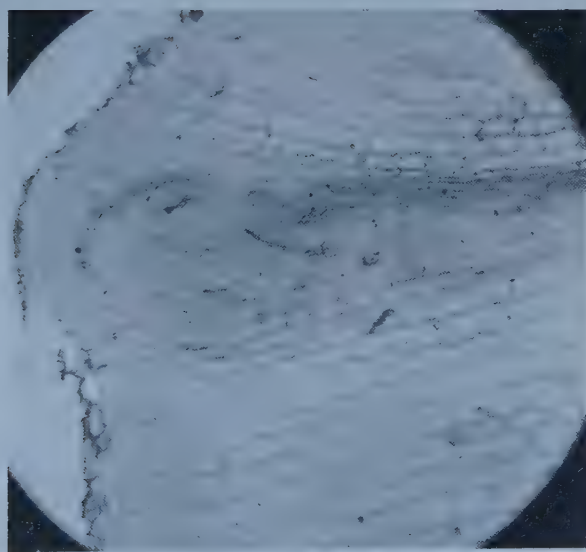


FIG. 3.

ADDITIONS TO THE FLORA OF ORKNEY, AS RECORDED IN
WATSON'S "TOPOGRAPHICAL BOTANY," Second Edition
(1883). By Colonel H. H. JOHNSTON, C.B., C.B.E.,
D.Sc., M.D., C.M., F.R.S.E., F.L.S.

(Read 17th June 1926.)

This paper forms a continuation of eight papers on the same subject, one of which I read before the Scottish Natural History Society on 4th April 1895, and which was published in "The Annals of Scottish Natural History," No. 15, pp. 173-181 (July 1895), and the other seven before the Botanical Society of Edinburgh on 15th January 1914, 10th June 1920, 17th March 1921, 20th April 1922, 19th April 1923, 19th June 1924, and 19th June 1925, and which were published in the Society's "Transactions," vol. xxvi, pp. 207-217 (1914); vol. xxviii, pp. 23-42 (1920), pp. 51-66 (1921), pp. 98-117 (1922), and pp. 174-183 (1923); and vol. xxix, pp. 83-95 (1924), and pp. 151-170 (1925), respectively.

Before and after the publication of the second edition of Watson's "Topographical Botany," in 1883, several of the plants mentioned in the following list have been recorded from Orkney by me and other botanists; but as the value of botanical records is greatly enhanced by the possession of authentic specimens, I have included in this list the names of all specimens in my herbarium, which are either additional to or confirm doubtful records of the plants recorded from county No. 111 Orkney in the second edition of the above-mentioned book.

In the case of those plants which have already been recorded from Orkney, references are given in the following list, under each species and variety, to the books in which the records have been published. These records are principally contained in "A Tour through some of the Islands of Orkney and Shetland," in the year 1804, by Patrick Neill (1806); "Notice of some of the rarer Plants observed in Orkney during the Summer of 1849," by John T. Syme, Esq., published in the "Transactions of the Botanical Society of Edinburgh," vol. iv, pp. 47-50 (1850); "Florula Orcadensis—A list of plants reported to occur in the Orkney Isles," by H. C. Watson, Esq., F.L.S., published in "The Journal of Botany," No. xiii,

pp. 11-20 (January 1864); Annual Reports of the Botanical Exchange Club of the British Isles; "A new List of the Flowering Plants and Ferns of Orkney," edited by W. A. Irvine Fortescue, and published in "The Scottish Naturalist" (1882-1884); "Supplement to Topographical Botany," ed. ii, by Arthur Bennett, A.L.S. (1905); and "Flora Orcadensis," by Magnus Spence, F.E.I.S. (1914).

The nomenclature followed is that of the second edition of Watson's "Topographical Botany" (1883), except in the case of species and varieties which are not recorded in that work. In the latter case the nomenclature adopted is that of "The London Catalogue of British Plants," tenth edition (1908), except where otherwise stated. Non-native plants, which have become naturalised in Orkney, are distinguished by a * prefixed to the names, and the names of casuals are printed in italics.

Of the 18 species, varieties, and forms recorded from Orkney in the following list, 15 are native, and 3 are mere casuals introduced into Orkney through the agency of cultivation.

ABBREVIATIONS.

"Annals Scot. Nat. Hist."=The Annals of Scottish Natural History. Bennett, "Suppl. Top. Bot."=Supplement to H. C. Watson's Topographical Botany, second edition. By Arthur Bennett, A.L.S. (1905).

"Bot. Exch. Club Report" (separate Reports by the Secretary and Distributor)=Report of The Botanical Exchange Club of the British Isles, at present called The Botanical Society and Exchange Club of the British Isles.

"Journ. Bot."=The Journal of Botany.

"Lond. Cat."=The London Catalogue of British Plants.

Neill, "Tour"=A Tour through some of the Islands of Orkney and Shetland, in the year 1804. By Patrick Neill, A.M., Secretary to the Natural History Society of Edinburgh (1806).

"Scot. Nat."=The Scottish Naturalist.

Spence, "Flora Orcadensis"=Flora Orcadensis. By Magnus Spence, F.E.I.S. (1914).

Watson, "Top. Bot."=Topographical Botany, second edition. By H. C. Watson (1883).

CORRECTIONS.

In "Trans. Bot. Soc. Edin.," vol. xxviii, part i, p. 28 (1920), in lines 10 and 11 from top of page, for "*Lotus major*, Scop. [= *L. uliginosus*, Schkuhr.] (*vide* Arthur Bennett)," read *Lotus*

major, Scop., var. *b. glaber*, Bréb. [= *L. uliginosus*, Schkuhr, var. *b. glaber*, Bréb.] (*fide* G. C. Druce, 17th December, 1922).

In "Trans. Bot. Soc. Edin.," vol. xxviii, part iii, p. 114 (1922), in line 9 from top of page, *after* "Mainland," *add* 12th August 1921, H. H. Johnston.

In "Trans. Bot. Soc. Edin.," vol. xxix, part i, p. 91 (1924), in line 3 from top of page, *for* "51" *read* 13.

In "Trans. Bot. Soc. Edin.," vol. xxix, part ii, p. 157 (1925), in line 14 from bottom of page, *for* "*Sonchis*" *read* *Sonchus*.

In "Trans. Bot. Soc. Edin.," vol. xxix, part ii, p. 162 (1925), in line 12 from top of page, *for* "PULCHELLA" *read* PULCHELLA, and *for* "PURPURELLA" *read* PURPURELLA.

In "Trans. Bot. Soc. Edin.," vol. xxix, part ii, p. 165 (1925), in line 4 from bottom of page, *for* "ten" *read* two.

In "Trans. Bot. Soc. Edin.," vol. xxix, part ii, p. 166 (1925), in line 6 from top of page, *after* "Nos. 1854," *add* 2520.

CLASS I.—DICOTYLEDONS.

ROSA OMISSA, *Déséglise*, var. *b. SHERARDI*, *Wolley-Dod*, *form SUBMOLLIS*, *Wolley-Dod*, in "The Roses of Britain," p. 81 (1924) (*fide* A. H. Wolley-Dod, 25th November 1925).—Heathery and grassy cliffs at seashore, 20 feet above sea-level, between Lee Craig and Stanger Head, Hoxa Sound, Flotta, Reference No. 2843, 26th September 1924 (plants in ripe fruit), and Reference No. 3192, 14th September 1925 (plants in unripe fruit and sparingly in ripe fruit), H. H. Johnston. Native. Rare. Ripe fruit red. A new record for this variety and form for H. C. Watson's county No. 111 Orkney, discovered by me on 26th September 1924.

Ribes rubrum, Linn., var. *a. sativum* (Reichb.).—Reference No. 2994, grassy shrubby banks at burnside, 20 feet above sea-level, South Burn of Quoys, Hoy, 13th June 1925, H. H. Johnston. Not native. Very rare. Plants in young unripe fruit on 13th June 1925, and sparingly in ripe fruit on 28th July 1925. *Ribes rubrum*, Linn., is recorded from Berriedale, Hoy, by the late Dr. A. R. Duguid in his manuscript "Flora Orcadensis" (1858), but I have never seen this species growing wild, either at Berriedale or elsewhere in Orkney, since I began botanising in 1874, until James Sinclair, junior, aged 11 years, residing at the Bu, Hoy, showed me the station

for it at the South Burn of Quoys, Hoy, on 13th June 1925. See "Scot. Nat.," No. xlviii, p. 364 (October 1882).

Peucedanum Ostruthium, Koch (name confirmed by Arthur Bennett on 12th September 1925).—Reference No. 3118, artificial grass lawn in a garden, 20 feet above sea-level, Established Church Manse, Hoy, 25th July 1925, H. H. Johnston. Not native. Very rare. Plants in flower-bud and flower. Leaves aromatic both when fresh and dried. Petals white.

Galium Mollugo, Linn. (*fide* Arthur Bennett, 12th September 1925).—Artificial grass lawn in a garden, 15 feet above sea-level, Established Church Manse, Hoy, Reference No. 2984, 12th June 1925 (plants not in flower or fruit), and Reference No. 3116, 25th July 1925 (plants in flower-bud and sparingly in flower), H. H. Johnston. Not native. Very rare. Leaves 6-8 in a whorl. Petals white. Mr. Arthur Bennett, in a note on my specimens, writes as follows:—"Leaves too broad for *erectum*! . . . Your plant is evidently a form of *Mollugo*; and I think is really a form between the type and the var. *b. insubricum* (Gaud.)." The leaves of this plant are *much broader* than those of my specimens of *Galium Mollugo*, Linn., var. *c. Bakeri*, Syme (*fide* Arthur Bennett and C. E. Salmon), from Deerness and Birsay, as recorded by me in "Trans. Bot. Soc. Edin.," vol. xxviii, part i, p. 31 (1920).

HIERACIUM SILVATICUM, *Gouan*, var. *i. SUBTENUE*, *W. R. Linton*, in "An Account of the British Hieracia," p. 41 (1905) (*fide* John Cryer, 22nd September 1925).—Reference No. 3138 A, heathery rocky crags at burnside, 180 feet above sea-level, Trowie Glen, Hoy, 28th July 1925, H. H. Johnston. Native. Rare. Plants in flower and unripe fruit. Corolla yellow. Style and its two recoiled branches brownish-yellow. A new record for this variety for H. C. Watson's county No. 111 Orkney, discovered by me on 28th July 1925.

The aggregate species *TARAXACUM OFFICINALE*, *Wiggers*, is recorded from Orkney in Watson, "Top. Bot.," ed. ii, p. 236 (1883), but the following six segregate species are not mentioned in that book:—

GROUP V.—SPECTABILIA.

TARAXACUM FÆRÖENSE, *Dahlstedt*, form *ANGUSTIFOLIA*, *Dahlstedt* (*fide* Ilugo Dahlstedt, who saw all my three dried

specimens of Reference No. 2957 B on 28th April 1926).—Reference No. 2957 B :—Natural, grassy, shell-sandy pasture near seashore, 15 feet above sea-level, Links of Boardhouse, Birsay, Mainland, 8th June 1925, H. H. Johnston. Native. Rare. Plants in full flower and sparingly in unripe fruit.

TARAXACUM NÆVOSUM, *Dahlstedt*, form *CROCATUM*, *Dahlstedt*.

A forma primoria antheris haud polliniferis corollis in videtur obscurioribus, foliis loborum figura paucum ad *T. nævosiforme* vergentibus diversum.

[I am indebted to Dr. Hugo Dahlstedt, Stockholm, Sweden, for the above description of this new form, described by him, on 4th May 1926, from my eight dried specimens of Reference No. 2950.]

Locality.—Reference No. 2950 :—Grassy roadside at sea-shore, 10 feet above sea-level, South End, Stromness Town, Stromness, Mainland, 5th June 1925, H. H. Johnston. Native. Common. Plants in flower and unripe fruit and sparingly in ripe fruit. Leaves dull green and spotted dark purplish above, paler green beneath, with a purplish-green midrib. Achenes brown, spinulose-muricate at the apex.

GROUP VI.—VULGARIA.

TARAXACUM CYANOLEPIS, *Dahlstedt*, in "Arkiv. för Botanik," Bd. 10, n. 11, p. 40 (Stockholm, 1911) (*vide* Hugo Dahlstedt, who saw all my six dried specimens of Reference No. 2903 and one dried specimen of Reference No. 2956 on 26th April 1926).—Grassy banks at roadside, 130 feet above sea-level, Clouster Brae, Stromness, Mainland, Reference No. 2903 (plants in full flower and sparingly in unripe fruit), 1st May 1925, and Reference No. 2956 (plants sparingly in fruit), 5th June 1925, H. H. Johnston. Native. Common. Leaves dull green and spotted dark purplish above, paler green beneath, with a purplish-green midrib. Achenes pale brown, spinulose-muricate at the apex. A new record for this species for H. C. Watson's county No. 111 Orkney, discovered by me (Henry Halcro Johnston) on 1st May 1925. Dr. Hugo Dahlstedt informs me that this species also grows in England, western Norway, south-west Sweden, and west Finland,

TARAXACUM HAMATIFRONS, *Dahlstedt*, n. sp.

Folia saturate viridia, subtus pallidiora, supra \pm maculata, oblongo-lanceolata—lanceolata lobis aequalibus deorsum decrescentibus, hamatis, angustis—latiusculis, \pm acutis, \pm approximatis, superioribus integris inferioribus \pm dentatis, lobo terminali sagittato marginibus convexis integris, obtusiusculo, in fol. ext. minore in fol. int. majore, petiolis et nervo mediano \pm violascentibus.

Scapi glabri—subglabri, \pm colorati, folia aequantes—superantes.

Involucrum breve \pm crassum, atroviride, basi ovato—truncata.

Squamae exteriores \pm reflexae, lanceolatae—anguste ovato-lanceolatae, acutae, extus atrovirides, intus pallidiores et saepe \pm violascentes, apice \pm purpureae, interiores lineares acutae apice \pm purpurascentes.

Calathium 30–40 mm. diametro.

Ligulae luteae, marginales extus stria \pm atropurpurea notatae.

Antherae polliniferae.

Stylus et stigmata flavescentes.

Achenium obscure fusco-stramineum, c. 3 mm. longum, vix 1 mm. latum, inferne fere laeve, superne leviter tuberculatum, in pyramidem brevissimum conicam sensim abiens.

Rostrum c. 7 mm. longum.

This form bears in some degree, as regards to the spotted leaves, a resemblance to *Spectabilia*, but it reminds one of *Vulgaria* in its fruits. Probably it belongs to the latter group. In the form of the leaves and their lobes it is very like *T. hamatum*, but differs especially from it through its narrow, recurved, not margined outer phyllaries.

[I am indebted to Dr. Hugo Dahlstedt, Stockholm, Sweden, for the above description and remarks on this new species, described by him, on 4th May 1926, from my seven dried specimens of Reference No. 2902, all of which have been seen by him.]

Locality.—Reference No. 2902 :—Grassy banks at roadside, 160 feet above sea-level, Clouster Brae, Stromness, Mainland,

1st May 1925, H. H. Johnston. Native. Common. Plants in full flower and sparingly in ripe and unripe fruit.

TARAXACUM TANYLEPIOIDES, *Dahlstedt*, n. sp.

A *T. tanylepide*, cui est sat affine, haec species foliis latioribus lobes plurimis longis potentibus—hamatis crebris, lobo terminali latiore et majore brevi, squamis exterioribus angustioribus haud marginatis saepius valde reflexis, interioribus sub apice callosis-leviter corniculatis nec non antheris ut videtur polliniferis satis esse distinctum videtur.

This form seems to be very nearly allied to *T. tanylepis*, but seems to differ from it especially through its broader leaves with longer lobes, short broad end lobes and polliniferous anthers.

[I am indebted to Dr. Hugo Dahlstedt, Stockholm, Sweden, for the above description and remarks on this new species, described by him, on 5th May 1926, from my five dried specimens of Reference No. 2959, all of which have been seen by him.]

Locality.—Reference No. 2959 :—Shell-sandy banks at sea-shore, 10 feet above sea-level, Links of Boardhouse, Birsay, Mainland, 8th June 1925, H. H. Johnston. Native. Common. Plants sparingly in flower and fruit mostly shed. Fruit-receptacle flattish-convex. Achenes pale brown, spinulose-muricate at the apex. My specimens were collected at the same station as those of the form of this species, Reference No. 2900, in flower, 1st May 1925 (see p. 304).

Reference No. 2957 (six dried specimens determined by Dr. Hugo Dahlstedt on 27th April 1926) :—Natural, grassy, shell-sandy pasture near seashore, 15 feet above sea-level, Links of Boardhouse, Birsay, Mainland, 8th June 1925, H. H. Johnston. Native. Common. Plants moderately in flower and sparingly in fruit. Leaves dull green and not spotted above, paler green beneath, with a purplish-green midrib. Outer phyllaries recurved both in flower-bud and in the fully expanded flower; inner phyllaries adpressed below, recurved above in the *fully expanded flower*, simple (not gibbous or appendaged) at the dark purple apex. Corolla yellow, striped dull purple beneath in the outer florets. Style and its two

recurved or recoiled branches yellow. Achenes brown, spinulose-muricate at the apex.

TARAXACUM TANYLEPTOIDES, *Dahlstedt, form* (*fide* Hugo Dahlstedt, who saw all my nine dried specimens of Reference No. 2900 on 27th April 1926).—Reference No. 2900:—Shell-sandy banks at seashore, 10 feet above sea-level, Links of Boardhouse, Birsay, Mainland, 1st May 1925, H. H. Johnston. Native. Common. Plants moderately in flower. Leaves dull green or dull purplish-green and not spotted above, paler green beneath, with a purplish-green midrib. Outer phyllaries recurved both in flower-bud and on the fully expanded flower, dull purplish-green; inner phyllaries adpressed, simple (not gibbous or appendaged) at the dull crimson-purple apex. Corolla yellow, striped dull purple beneath in the outer florets. Style and its two recoiled branches yellow. My specimens were collected at the *same station* as those of the type of the species, Reference No. 2959, sparingly in flower and fruit mostly shed, 8th June 1925 (see p. 303).

TARAXACUM ORCADENSE, *Dahlstedt, n. sp.*

Folia saturate viridia, subtus pallidiora, supra immaculata, \pm lata, obovato-oblonga—oblonga, exteriora angustiora lingulato-lanceolata lobis brevibus deltoideis integris—denticulatis praedita, interiora magis magisque lata lobis crebris superne latioribus deltoideis—subhamatis in margine superiore \pm convexo denticulatis—integris, \pm acutis, lobo terminali plerumque magus—maximo ovato—sagittato integro v. interdum ad basim \pm dentato, breve acuto, mucronato, petiolis et nervo mediano \pm violascentibus.

Scapi plures, folia aequantes—superantes, glabri, \pm colorati.

Involucrum breve, crassum, atrovirens, basi \pm ovato-truncata.

Squamae exteriores \pm reflexo-patentes anguste ovato-lanceolatae in pag. exteriore atrovirides, in pag. interiore pallidiores et saepe \pm violascentes, interiores e basi latiore \pm lineares apice obtusiusculo \pm coloratae.

Calathium 40–45 mm. diametro.

Ligulae luteae, marginales extus stria brauneo-violacea ornatae,

Antherae polliniferae.

Stylus et stigmata flavescentes.

Belongs to *Vulgaria*.

[I am indebted to Dr. Hugo Dahlstedt, Stockholm, Sweden, for the above description of this new species, described by him, on 4th May 1926, from my dried specimens of Reference Nos. 1550 (4 specimens), 2920 (20 specimens), and 2986 (4 specimens), all of which have been seen by him.]

Locality.—Reference Nos. 1550 and 2920 :—Grassy ditch at roadside, 150 feet above sea-level, Tiffyhall, Deerness, Mainland, Reference No. 1550 (plants sparingly in flower), 21st April 1922, and Reference No. 2920 (plants in full flower), 12th May 1925, H. H. Johnston. Native. Common.

Reference No. 2986 :—Rocky crags on hillside, 700 feet above sea-level, north-east side of Ward Hill, Hoy, 12th June 1925, H. H. Johnston. Native. Rare. Plants in full flower.

Note.—None of my specimens of Reference Nos. 1550, 2920, and 2986 are in fruit; but, on 23rd June 1922, I collected achenes from plants growing at Tiffyhall, Deerness (the *same station* as for Reference Nos. 1550 and 2920), which are olive-brown in colour, and spinulose-muricate at the apex, and, as I found no other species of *TARAXACUM* at that station, these achenes are most probably those of *TARAXACUM ORCADENSE*, *Dahlstedt*.

CARDUUS PALUSTRIS, *Linn.*, var. *b. FEROX*, *Druce*, in "Bot. Exch. Club Secretary's Report for 1911," vol. iii, part i, p. 22 (April 1912) (*vide* G. C. Druce, 17th December 1922).—Heath, Naversdale, Orphir, Mainland, 9th August 1878, H. H. Johnston; and Reference No. 517, moist heathery hillside, 750 feet above sea-level, Ward Hill, Hoy, 28th August 1919, H. H. Johnston. Native, common, and plants in full flower at both stations in two different islands. Confirms Dr. G. Claridge Druce's record of this variety for H. C. Watson's county No. 111 Orkney ("Birsay, Hoy, etc., Orkney"), in "Bot. Exch. Club Secretary's Report for 1920," vol. vi, part i, p. 131 (September 1921).

CLASS II.—MONOCOTYLEDONS.

POTAMOGETON PERFOLIATUS, *Linn.*, var. *ROTUNDIFOLIUS*, *Wallroth* (*vide* Arthur Bennett, 23rd September 1913).—Mud at

bottom of water in a loch, 15 feet above sea-level, Loch of Saintear, Westray, 23rd August 1913, H. H. Johnston; mud at bottom of water in a loch, 40 feet above sea-level, Loch of Burness, Westray, 27th August 1913, H. H. Johnston; and mud at bottom of water in a loch, 8 feet above sea-level, Loch of Saint Tredwall, Papa Westray, 4th September 1913, H. H. Johnston. Native, and plants in ripe fruit at all these three stations in two different islands. Mr Arthur Bennett, in a note on my specimens from the above-mentioned three stations, dated 23rd September 1913, writes:—"All good examples" of this variety. A new record for this variety for H. C. Watson's county No. 111 Orkney, discovered by me on 23rd August 1913.

POTAMOGETON HETEROPHYLLUS, *Schreb.*, var. PAUCIFOLIUS (*Opiz*) (*vide* Arthur Bennett, 21st October 1925).—Reference No. 3199, mud at bottom of clear fresh water, 5 feet deep, in a loch near sea-level, Loch of Harray, near Mill of Rango, Sandwick, Mainland, 23rd September 1925, H. H. Johnston. Native. Rare. Plants in fruit. A new record for this variety for H. C. Watson's county No. 111 Orkney, discovered by me on 23rd September 1925.

POTAMOGETON NITENS, *Weber*, var. *d.* CURVIFOLIUS (*Hartm.*). (*vide* Arthur Bennett, 21st October 1925).—Mud at bottom of clear water, $1\frac{1}{4}$ –2 feet deep, in a loch, 30 feet above sea-level, Loch of Rango, Sandwick, Mainland, Reference No. 3174, 28th August 1925 (plants in flower), and Reference No. 3204, 23rd September 1925 (plants in withered flower and no fruit developed), H. H. Johnston. Native. Common. A new record for this variety for H. C. Watson's county No. 111 Orkney, discovered by me on 28th August 1925.

SLEROCHLOA MARITIMA, *Lindley*, subvar. SUBCÆSPITOSA, *Druce*, in "Bot. Exch. Club Secretary's Report for 1917," vol. v, part i, p. 62 (September 1918) (*vide* G. C. Druce, 7th August 1920).—Rocky seashore, 5 feet above sea-level, west side of Aith Hope, Waas, Hoy, 4th August 1913, H. H. Johnston; and gravelly seashore, 5 feet above sea-level, Hamla Voe, Stromness, Mainland, 30th June 1914, H. H. Johnston. Native, common, and plants in full flower at both stations in two different islands.

CLASS III.—CRYPTOGAMS.

CHARA MUSCOSA, *Groves et Bullock-Webster*, in "Journ. Bot.," vol. lxii, p. 33, tab. 570 (February 1924) (*vide* James Groves, who saw all my specimens on 1st November 1925).—Reference No. 3176, mud at bottom of clear water, $1\frac{1}{2}$ foot deep, in a loch, 30 feet above sea-level, Loch of Rango, Sandwick, Mainland, 28th August 1925, H. H. Johnston. Native. A new record for this species for Britain and H. C. Watson's county No. 111 Orkney, discovered by me (Henry Halcro Johnston) on 28th August 1925, and recorded by me in "Journ. Bot." vol. lxiv, p. 80 (March 1926). The three following species (all identified by Mr. James Groves on 1st November 1925) were also collected by me in the Loch of Rango, on the same date, 28th August 1925, namely:—CHARA CONTRARIA, *Kützing*, CHARA ASPERA, *Willdenow*, and CHARA DESMACANTHA, *Groves et Bullock-Webster*. See "The British Charophyta," by James Groves and G. R. Bullock-Webster, vol. ii, pp. 43–44 (1924), where it is recorded that CHARA MUSCOSA, *Gr. et B.-W.*, was discovered in Lough Mullaghderg, West Donegal, Ireland, by Canon G. R. Bullock-Webster, in July 1917.

OBITUARY NOTICES.

JEAN MASSART.

The death of Professor Massart, an Honorary Fellow of the Society, is a severe loss to Botany. Born near Brussels in 1865, he became Professor of Botany there in 1895, succeeding the distinguished plant-physiologist, Léo Errera. One of Massart's earlier publications was a pioneer summary on "Parasitism, Organic and Social," translated into English in 1895, a correlation of the phenomena of parasitism in plants and animals with social problems. This broad biological outlook extends through all his work, and he has left unfinished "Eléments de Biologie Générale et de Botanique," the wide scope of which is indicated by the title. His more intensive studies were on plant geography and ecology, as represented by "Esquisse de la Géographie Botanique de la Belgique" (1910), over 300 pages of text and about 500 photographs. The ecological side of botany appealed strongly to Professor Massart, and he was one of the international party that spent five weeks in Britain in 1911. There is in all his work something incisive and stimulating. Such a vigorous personality was not likely to submit weakly to the invasion of Belgium in 1914, hence it was no surprise to find him active in propaganda, followed by escape and an enforced period of exile in the south of France, whence he published some impressions of the ecology of that area. The many who knew Professor Massart will appreciate how much Botany has lost by his death at a comparatively early age.

W. G. S.

THOMAS BENNET CLARK, J.P., C.A.

The late Thomas Bennet Clark was one of the oldest members of the Botanical Society, having been elected in June 1873. He continued during his whole life to take an active interest in Botany, and gave much attention to the practice of horti-

culture, spending his spare time in his garden at Newmills near Balerno, lying at an altitude of about 500 feet. To the care of his garden, in which it was his delight to work, he brought the scientific and patient mind of the botanist. It was always a joy seasoned with instruction to wander round the garden in his company, noting his pride in success achieved often after years of effort. An enthusiastic collector and cultivator, he frequently exhibited specimens of interest which came under his observation.

Mr. Clark served many times on the Council, and was President of the Society for the period 1908-1910. He contributed occasionally to the Society's Transactions, his last paper dealing with an interesting seedling of *Cytisus Adami* (Trans., xxviii, pt. iii, 1921-1922). He was a regular attender at the meetings, and his cheerful and friendly presence will be greatly missed.

Currie Churchyard, where his remains were laid to rest on Saturday, 19th June, is near the scene of his cherished botanical rambles. His only son has inherited his father's love of science and nature, and is now assistant to the Professor of Botany in Trinity College, Dublin. R. C. M.

JAMES WHYTOCK.

By the death of Mr. J. Whytock, V.M.H., the Botanical Society of Edinburgh loses a member who took a deep interest in the proceedings of the Society, and who during the three years 1917 to 1920 acted as its President. Mr. Whytock was born on the 19th July 1845, and followed the profession of his father, who was then head gardener to Lady Keith at Tullyallan.

After leaving home, his first position as a young gardener was at Oxenfoord Castle, the residence of the Earl of Stair. From there he proceeded to Dalkeith as plant foreman under Mr. William Thomson. Leaving Dalkeith, he was appointed head gardener to Viscount de Vesci at Abbey Leix, Queen's County, Ireland. Thereafter he went to Coolattin Park, Co. Wicklow, where he did much to make this celebrated garden famous during a long service of twenty years. At the death of Mr. Malcolm Dunn he was selected by the Duke of Buc-

cleuch to take charge of the gardens at Dalkeith in 1899, which position he occupied until his retiral in 1921. During this long period he maintained these gardens at a high standard of excellence. Mr. Whytock took a keen interest in all subjects pertaining to his profession, and was an influential member of many gardening societies.

From 1908 to 1910 he was President of the Scottish Horticultural Association, among the members of which he made many friends by his kindly unassuming manner and the keen interest he took in all that was likely to lead to the advancement of the Association. He was awarded the Neill Prize by the Royal Caledonian Horticultural Society in 1906.

In 1914 he was honoured by the Royal Horticultural Society, who awarded him the Victoria Medal of Honour in Horticulture. At the large shows at Chelsea held by this Society he had acted as a judge for a considerable number of years.

Many of the younger generation of gardeners had reason to be grateful to Mr. Whytock for the interest he took in their future welfare, sparing himself no trouble in his efforts for their advancement.

The genus *WHYTOCKIA*, W. W. Sm., was named in honour of Mr. Whytock in 1919, the description being published in the *Transactions* of this Society of that year. R. L. H.

TRANSACTIONS
OF THE
BOTANICAL SOCIETY OF EDINBURGH

SESSION XCI

PRESIDENTIAL ADDRESS—SOME REFLECTIONS ON THE NATURE
OF SPECIES. By Professor MONTAGU DRUMMOND, M.A.,
F.L.S., F.R.S.E.

(Read 21st October 1926.)

This address is not in any sense an original contribution to our knowledge of the nature of species. All that it is intended to be is a brief, non-technical; and therefore necessarily incomplete¹ account of some of the changes which the concept of the biological species has undergone since it was first established by Linnaeus.

At the present day it is clearly impossible to deal with the question of species apart from the problem of evolution. But it will be convenient to restrict the argument to such aspects of evolutionary theory as bear most directly upon the narrower problem. These aspects, moreover, will have to be disposed

¹ The most serious omission entailed by non-technical treatment is the absence of any reference to cytological phenomena. It must suffice to note that those cytological data which have an obvious bearing on the species problem tend to strengthen the Mendelian position. For reasons given in the text (p. 324), Hybridisation, while admittedly giving rise to new forms, cannot be regarded as the *only* mode of origin of species; the omission of cytological evidence does not, therefore, really affect the main argument of this address. I have thought it permissible to assume that every reader will be familiar with the elements of Mendelism.

of in a very summary fashion, without detailed discussion of the evidence, and with as little digression as possible into matters of a controversial nature.

Linnaeus, either unaware of the possibility of an evolutionary origin of the living world, or, more probably, rejecting that possibility deliberately, was able to give a perfectly unequivocal and, in his day, generally acceptable definition of a species. In his "Philosophia Botanica" (1750), under Aphorism No. 157, he states that "We recognise just as many species as there were different forms (*i.e.* types) created in the beginning" ("Species tot numeramus, quod diversae formae in principio sunt creatae"). This idea is further developed in the "Notes" on the Aphorism, as follows: "Species are all those diverse forms which the Infinite Being produced in the beginning; each of these forms has produced, in accordance with the laws of generation, more like unto itself. Hence there are as many species as there are at the present day different forms and structures" ("Species tot sunt, quot diversas formas ab initio produxit Infinitum Ens; quae formae, secundum generationis inditas leges, produxere plures, at sibi semper similes. Ergo species tot sunt, quot diversae formae s. structurae hodiernum occurrunt"). The main interest of this Note lies in the fact that it suggests that Linnaeus had in mind *both* of the two principal criteria of specific identity, namely, (1) the *morphological* criterion of structural similarity, and (2) the *genetical* criterion of "faithful reproduction," *i.e.* the property of breeding true to type.

The official Linnaean definition of a Variety is given in Aphorism No. 158, which reads: "Varietates tot sunt, quot differentes plantae ex ejusdem speciei semine sunt productae." The exact significance of this Aphorism is doubtful. The meaning of the accompanying Note, however, seems to be sufficiently clear, to wit: "A variety is a plant transformed by an incidental cause such as climate, soil, heat, wind, etc. . . . Varieties may differ from the parent species in size, doubleness, crispation, colour, taste, scent, etc. ("Varietas est Planta mutata a caussa accidentali: Climate, Solo, Calore, Ventis, etc. reducitur itaque in Solo mutato. Species varietatum sunt Magnitudo, Plenitudo, Crispatio, Color, Sapor, Odor").

This interpretation is supported by Aphorism No. 306, according to which "Varieties are plants belonging to one

species, which have been transformed by some casual influence" ("Varietates sunt plantae ejusdem speciei, mutatae a caussa quiacunque occasionali").

Mention must finally be made of the famous Aphorism No. 310, "Varietates levissimas non curat Botanicus." From the Notes to this last-mentioned Aphorism it appears that Linnaeus was here referring to the so-called "varieties" of cultivation. He was evidently aware that these cultivated races did not fit into his scheme of units; and it is known that quite early in his career he had intended to carry out culture experiments with such races in order to test their constancy. Whether from lack of time or for other reasons, that intention was never carried out.

The concept of species established by Linnaeus remained virtually unchallenged for nearly one hundred years. About the middle of the nineteenth century, however, the Linnaean position was assailed from several different directions. The three most formidable attacks are associated respectively with the names of Darwin, of Jordan, and of Mendel.

The Darwinian Theory clearly cuts at the root of the Linnaean definition of species, inasmuch as it altogether denies the separate creation of each species and postulates in place of this supernatural act the natural process of evolution by descent. It is, however, important to note at once that the idea of evolution *as such* is not necessarily incompatible with the conception of species as real, sharply separated entities. It is only the final form of Darwin's theory, in which all the weight is laid upon the natural selection of individual variations, that denies to the Linnaean species any actual existence as a unit differing *in kind* from the variety or the individual. For Darwin certainly recognised the existence of two kinds of variation among organisms, viz. (a) "Fluctuating variation," expressed in "individual differences" (now called "modifications"), and (b) "single variations" or "chance variations" (now termed "mutations"), and to begin with he seems to have believed that *both* these forms of variability could provide material for natural selection to act upon. Later he put his faith almost entirely in the slight individual differences. Among the considerations which induced him thus to narrow the basis of his theory were, first, the attitude of A. R. Wallace, who consistently maintained that individual

variations, when acted on by natural selection, were amply sufficient to account for the origin of all species, and regarded single variations as of no importance in evolution; and, secondly, the purely mathematical criticism of Fleeming Jenkin, which seemed to Darwin to show that "single variations" could have little chance of surviving in the struggle for existence, even under favourable conditions.¹

In so far as the species concept is concerned then, the logical consequence of Darwin's later attitude towards variation was the negation of the actuality of species or, at any rate, the refusal to admit that the species forms a separate grade distinct in kind from the variety or even from the individual. Numerous passages in the "Origin of Species"—especially in the second chapter, which is largely concerned with this point—show that Darwin was forced to take this logical step, as it were, against his will. The following excerpts from the "Origin of Species" ² illustrate Darwin's final position:—

" . . . I look at the term species as one arbitrarily given for the sake of convenience to a set of individuals closely resembling each other . . . it does not essentially differ from the term variety, which is given to less distinct more fluctuating forms. The term variety, again, in comparison with mere individual differences, is also applied arbitrarily, and for mere convenience sake."

" Finally, then, varieties have the same general character as species, for they cannot be distinguished from species, except, firstly, by the discovery of intermediate linking forms, and the occurrence of such links cannot affect the actual characters of the forms which they connect; and except, secondly, by a certain amount of difference,³ for two forms, if differing very little, are generally ranked as varieties, notwithstanding that intermediate linking forms have not been discovered, but the amount of difference considered necessary to give to two forms the rank of species is quite indefinite."

¹ For one argument to the contrary, see Willis, "Age and Area," p. 212.

² The quotations are from the last edition; in the earlier editions the insistence on the outstanding importance of "individual differences" is not so marked.

³ The phrase "by a certain amount of difference" is obscure; presumably what is meant is "by a certain difference in the degree of distinctness."

In the concluding chapter of the book Darwin uses a particular case to drive home his point: "It is quite possible," he says, "that forms now generally acknowledged to be merely varieties may hereafter be thought worthy of specific names, as with the primrose and cowslip¹; and in this case scientific and common language will come into accord. In short, we shall have to treat species in the same manner as those naturalists treat genera, who admit that genera are merely artificial combinations made for convenience. This may not be a cheering prospect; but we shall at least be freed from *the vain search for the undiscovered and undiscoverable essence of the term species.*"

Perhaps the most categorical statement of Darwin's "official" view is the following ("Origin of Species," ch. ii): "Certainly no clear line of demarcation has as yet been drawn between species and sub-species—that is, the forms which in the opinion of some naturalists come very near to, but do not quite arrive at, the rank of species; or again, between sub-species and well-marked varieties or between lesser varieties and individual differences. These differences blend into each other in an insensible series; *and a series impresses the mind with the idea of an actual passage.* Hence I look at individual differences, though of small interest to the systematist, as of high importance for us, as being the first step towards such slight varieties as are barely thought worth recording in works on natural history. And I look at varieties which are in any degree more distinct and permanent, as steps leading to more strongly marked and more permanent varieties; and at these latter, as leading to sub-species and to species."

The two last-quoted extracts are peculiarly interesting. The passage from Chapter II which I have placed last—in particular the phrase "a series impresses the mind with the idea of an actual passage"—gives the keynote of the whole argument of the book, in which Darwin is less concerned with the species question as such than with the demonstration of the evolution of all living forms by descent from common ancestors. The passage from the final chapter—in particular the phrase "the vain search for the undiscovered and undiscoverable essence of the term species"—clearly implies that

¹ The Primrose and the Cowslip are indeed now commonly treated as distinct species.

Darwin could not admit that the Linnaean species had any actual existence. Nevertheless, other passages in the "Origin of Species" show that Darwin was not finally convinced that species were merely conventional units. Thus in the fourth chapter, when dealing with the "Difficulties of the Theory," he says: "To sum up, *I believe that species come to be tolerably well-defined objects*, and do not at any one period present an inextricable chaos of varying and intermediate links"; and he goes on to state what he believes to be the causes of this relative distinctness of species, chief among these being the extinction of intermediate varieties.

It would be impertinent to dwell, at the present day, upon the high value to Biology and to scientific thought in general of Darwin's documentation of the idea of evolution, which previously had been mainly a speculative conception. The almost universal acceptance of his particular view of the *mechanism* of evolution, on the other hand, was by no means so beneficial in its effects. One result was a tendency on the part of many biologists to indulge in broad—and sometimes loose—phyletic speculation, and to neglect exact genetic experiment. Taxonomy was left comparatively unaffected, the systematists holding on to the idea of the reality of Linnaean species by a sort of instinct, an attitude which later experience has to a considerable extent justified.

Alexis Jordan attacked the Linnaean concept of the species from a different angle. He claimed to have shown, on the basis of cultural experiments combined with minute morphological analysis, that many Linnaean species, commonly regarded as homogeneous, were really composed of a number—sometimes a very large number—of smaller units, which, so he found, retained their distinctive features in cultivation and perpetuated themselves unchanged when grown from (selfed) seed. Here the attack, as compared with that of Darwin, is on another part of the Linnaean position. It is not the immutability of the units that is in question—on the contrary, Jordan and his school were the most irreconcilable opponents of Darwinism,—but the rank of the immutable units; according to Jordan, it is not the Linnaean species but his own "*petites espèces*" (the "*elementary species*" of De Vries, "*Jordanons*" of Lotsy) that represent those units. As examples of the effects of Jordanian analysis, it may be mentioned that he

subdivided *Cardamine pratensis*, Linn., into 3 petites espèces, *Ranunculus acris*, Linn., into 6, *Thlaspi alpestre*, Linn., into 16, *Erophila verna*, Linn., at first into about 30 and later into more than 200.

Jordan's work had little effect at the time upon the Darwinians, owing to the uncompromising adherence of the Jordan school to their belief that species were immutable, a view which we now know to have been perfectly justified, as far as *their* species were concerned. The systematists were also for the most part not impressed. They doubtless regarded Jordan as a troublesome "species-splitter," and certainly a Jordanian Flora, say of Europe, is scarcely a handy work for ordinary taxonomic purposes. But the entire neglect of the cultural test of specific constancy in which systematists have persisted almost until to-day has undoubtedly been a mistake.

Gregor Mendel's classical experiments are too well known to require detailed discussion here. The principal novel facts and ideas bearing on the species problem discovered by him are as follows:—

1. The possibility of the appearance of "new" forms after a cross, through redistribution of parental characters.
2. The concept of "particulate inheritance."¹
3. The fact that the "phenotype"² (the plant as defined by its somatic characters, in other words, the plant as we see it) and the "genotype"² (the hereditary type to which the plant belongs, as defined by the constitution of its gametes) are two different things.

Mendel's discoveries, which completely revolutionised our ideas about hybrids and laid the foundations of the science of Genetics, were very largely due to his use of the method of "Pedigree Breeding," i.e. the following out of the pedigree of each individual from generation to generation. As a matter of fact, although Mendel was the first to apply this method to the study of hybridisation, *selection* by Pedigree Culture, which embodies the same principle, had been utilised by several practical breeders long before Mendel's time.

¹ i.e. the view that the heritable characteristics of a race do not constitute an indivisible whole, but that they may be analysed into distinct portions—"unit-characters," "factors," or "genes"—which may be inherited independently of one another.

² These terms are due to Johannsen.

The two methods of selection practised by plant-breeders are (1) Selection in bulk or "Mass Selection," and (2) Selection of individual parents or "Line Selection." In the case of mass selection *a number of plants* are chosen as the parents of the next generation and the seed of all of them is "bulked," *i.e.* sown as one lot. If, for example, the object of selection is to increase the size of the seed, as many seeds above a certain size as are required are taken, irrespective of the plants from which they are derived, and sown out together. As every breeder knows, considerable improvement of a race can be effected in this way, *provided selection to the same standard is repeated in each generation*. As soon as selection ceases, on the other hand, the "improved" race gradually returns to its original level. It is necessary, therefore, in practice, for the breeder to retain a rigorously selected "élite" stock in his own hands and to allow for a certain amount of deterioration in the multiplied stocks which he sells to the public. Thus in the case of Sugar-beet, if it were desired to provide the commercial grower with seed which could produce roots with an average cane-sugar content of 16 per cent., the élite stock roots (assumed to be the grandparents of the commercial seed-bearers) would require to have an average sugar-content of not less than 20 per cent.

In line selection *a single plant* is chosen as a parent; precautions are taken to ensure that it shall be self-pollinated; and the seed thus produced is sown separately. The race isolated in this way is known as a "line." In the case of a plant which under normal conditions is perpetually self-pollinated—such as Oat, Wheat, or Barley—any line isolated in the manner described will be found to be quite uniform—every plant resembling the common parent in essential features—and to breed true indefinitely, thus constituting what is known as a "Pure Line." If the plant in question is normally cross-pollinated, but capable of continued self-pollination (*e.g.* Swede), it is very unlikely that the first generation of a line will turn out to be "pure"; in such cases several generations of line selection are generally required before a uniform race is obtained. The practically important feature of line selection lies in the fact that by this method (and by no other method of selection) it is possible to obtain perfectly constant strains—which are unaffected by further selection and consequently

also by the absence of further selection—in the most favourable case in a single generation.

Mass selection was for long the sole method used by the majority of commercial breeders, and is still the method most widely practised by them. The main reasons for this preference are, no doubt, first, the circumstance that this procedure admits of rapid multiplication of stocks, and, secondly, the fact that it necessitates “repeat orders” on the part of the grower, who is forced to obtain fresh stocks of selected seed at frequent intervals because of the inevitable “regression” of his own derived stock. Certain private breeders¹ in the late eighteenth and the early nineteenth centuries, however, discovered the peculiar advantage of the method of individual selection empirically, and about 1895 H. Nilson, Director of the Svalöf Crop-breeding Station, finally established this method as the only effective means of obtaining permanently improved races of crop-plants.²

The scientific proof of the Pure Line principle was furnished by Johannsen of Copenhagen in 1903 by means of very exact experiments with French Beans and with Barley.³ The novel feature of Johannsen’s experimental method was that it combined pedigree culture with “biometry,” *i.e.* the statistical analysis of measurable characters (such as the weight or size of Bean seeds or the percentage of congenitally abortive grains in Barley ears). The principal new facts ascertained by him were :

1. That selection *within a pure line* has no effect.
2. More generally, that selection does not *produce* new races in any circumstances, but merely leads to the separation of distinct races which already existed in a mixed stock.
3. That the “genotype,” *i.e.* the permanent hereditary constitution of the race as distinguished from the transitory character of the individual or “phenotype” (see above, p. 317), is ordinarily immutable.

¹ Le Couteur of Jersey, Shirreff of Haddington, and A. P. de Vilmorin of Paris.

² For a full account of the history of the Pure Line Concept, see De Vries : “Plant Breeding,” 1907.

³ The most accessible account of Johannsen’s classical experiments is to be found in Babcock and Claussen, “Genetics in Relation to Agriculture.” Though marred by some errors, it gives an adequate summary of the main evidence.

The pure lines of cultivation evidently correspond on the one hand to the "elementary species" or "Jordanons" which exist in nature, and on the other hand to the "homozygous races" of the Mendelians.

From the point of view of evolutionary theory in general the main implications of the pure line principle are (1) the immutability of the genotype, and (2) the non-inheritance of modifications. As far as the species concept was concerned, the discovery of pure lines confirmed the Jordanian view, according to which the Linnaean species is commonly a composite entity, comprising within itself a number of "petites espèces" which are the actual units. If we accept the conclusion that these ultimate units—Jordanons, pure lines or homozygous races—actually exist and that they are ordinarily immutable, we must consider anew the following fundamental questions:—

1. What are the actual units upon which evolution works?
2. In what way or ways do new units of this kind arise?
3. Is the Linnaean species a real entity or merely a conventional grouping of genuine units?

The quickest, and for our immediate purpose the most convenient, method of reviewing the evidence relevant to these questions is to consider very briefly the bearing upon them of the views of representatives of some of the leading Post-Darwinian schools of evolutionary theory.

De Vries¹—the protagonist of what may be called the Mutationist school—lays stress upon the fact that modifications are not inherited, and hence provide no basis for artificial or for natural selection. He points out, on the other hand, that "sports" or, as he terms them, "mutations" (Darwin's "single variations") are relatively frequent, at any rate among cultivated plants, and that these variations are undoubtedly heritable. The classical instance of mutation is the sudden appearance of *Chelidonium laciniatum*, Miller, in the sixteenth century. This plant, which differs from *Ch. majus*, Linn., in its laciniated leaves and petals, was discovered about 1590 by Sprenger, an apothecary of Heidelberg, in his medicinal garden. He sent specimens to the two Bauhins, to Clusius, and to other prominent botanists of his day, to all of whom it was previously unknown. The plant has never been found in the wild state, and, so far as is known, all the existing specimens are descend-

¹ "Die Mutationstheorie," 1901.

ants of Sprenger's original plant. From its first appearance the laciniated form has bred true from seed, and in particular has shown no tendency whatsoever to "revert" to the *Ch. majus* "type." From these facts De Vries not unreasonably concludes that *Ch. laciniatum* is a new species (in the Jordanian sense) which originated suddenly by mutation in 1590. Another instance cited by De Vries is that of the "Gaillon" Strawberry, *i.e.* the runnerless form of *Fragaria alpina*. This race is descended from a single runnerless plant discovered by P. P. A. de Vilmorin among seedlings of normal *Fragaria alpina*. This form was also seed-constant from the first. The crested and fimbriated forms of *Cyclamen latifolium*, which have appeared several times in cultivation (first recorded in 1827), are also regarded as well authenticated mutations by De Vries, on evidence provided by Thiselton-Dyer.¹

The characteristic features of mutations are as follows:—

1. They are discontinuous variations, *i.e.* there are no intermediates between them and the parent type; or, in other words, they arise "all at once," and not by gradual modification.

2. They may arise in any direction, *i.e.* they are not orientated with reference to the environment, or, in other words, they are not "adaptive."

3. They breed true from the first and indefinitely (apart from eventual further mutation).

De Vries's belief in the evolutionary importance of mutation was based, first, upon such historical data as those just quoted; secondly, upon his recognition of the non-inheritance of modifications; and thirdly, upon his own observations on the curious behaviour of an Evening Primrose, *Oenothera Lamarckiana*, which he found to be constantly giving rise to novel forms, some of which proved to be true-breeding, while others continued to "throw" fresh types. De Vries was perfectly familiar with Mendel's work; he was, in fact, one of the three biologists who, in 1900, simultaneously dragged Mendel's papers out of their long and undeserved obscurity. But at the time he was satisfied that his *Oenothera* novelties were not the result of segregation after a cross. From the three lines of evidence referred to he concluded generally that species—of the rank of Jordanons—always arise at one step, as it were

¹ Proc. Roy. Soc., vol. lxi.

ready-made, and that Natural Selection then acts on these new forms by weeding out the unfit.

From the Mutationist standpoint, *Oenothera Lamarckiana* has proved a broken reed. This plant is now known to be a hybrid, though one of a peculiar type. As the result of the collapse of one of the main props of De Vries's theory, the idea of mutation has fallen wholly into disrepute with many biologists, and notably with that section which may without offence be termed the Ultra-Mendelian school, to whom hybridisation is the sole and sufficient source of new species. It is, however, still permissible to believe in mutation as a real phenomenon, partly in view of such cases as that of *Chelidonium laciniatum*, in which the occurrence of previous hybridisation appears to be excluded, and partly because it seems difficult to account for evolution without assuming mutation as *one* factor in the process.

The Ultra-Mendelian view is developed in an entertaining, if not very convincing, manner by Lotsy in a short treatise entitled "Evolution by Hybridisation." There is much of wholesome criticism and stimulating suggestion in this book, but the main thesis is one which few biologists will be ready to accept without serious reservations. Lotsy censures both the systematists and the evolutionists for failing to give a clear definition of a species. In so doing he scores a dialectical point, but only by begging the question, since it will always be impossible to give a satisfactory definition of a species, on an evolutionary basis, until the major problem of evolution has been solved. Lotsy then proceeds to reject the Linnaean species as being no species at all. He also rejects the Jordanian species, because "faithful reproduction" (*i.e.* breeding true to type) is not necessarily proof of genetic purity, quoting as a case in point the instance of true-breeding albino mice, of which some races when mated with a black race give all-black offspring, whereas others, phenotypically indistinguishable, when mated with the same black race give all-grey offspring. After pointing out that there is no absolutely infallible test for genetic purity (complete homozygosity), he gives his own definition of a species, viz. "a group of individuals of identical constitution, unable to form more than one kind of gametes." This definition is open to serious criticism on a number of grounds. In the first place, it excludes the *possibility* of muta-

tion *ex hypothesi*. If we replace the phrase "unable to form more than one kind of gametes" by the more moderate clause "which do not form more than one kind of gamete" (*scilicet* "in the absence of eventual mutation"), the definition becomes less objectionable. Even so, as has been pointed out by the Hagedoorns¹ in a quaint simile, "To restrict the use of the term species for this special kind of species [*i.e.* the perfectly homozygous race]² is as inadmissible as the restriction of the term dog to coach dogs,³ to admit of the simple statement that dogs are white, spotted all over with black dots. Such a description will never be true of that group of animals which are called dogs by everybody else, and Lotsy's definition does not fit the majority of groups called species by systematic zoologists and botanists."

There is another and a more fundamental objection to Lotsy's definition of the species, viz. the fact that, while the perfect homozygote and the genetically pure race are perfectly legitimate conceptions, one may venture to doubt whether this ideal individual or race has ever been isolated. In this connection Johannsen⁴ makes the pertinent observation that the constitution of an individual for which several genes, say A, B, C, D, and E, have been analysed out, cannot be represented simply by $A+B+C+D+E$, but that the correct formula is $A+B+C+D+E+X$, where X is usually [if indeed not always ?] much more extensive than the portion of the constitution represented by the analysed genes. Oddly enough, Johannsen apparently believed that his own pure lines of Bean were perfectly homozygous, a claim which few Mendelians are likely to admit. Lotsy gives his whole position away when he states, what is perfectly true, that there is no absolutely infallible test of genetic purity. This fact should certainly prevent us from rashly assuming that a novel form is a mutation and not merely a Mendelian segregate; but it should make us equally cautious in asserting that any individual or race is perfectly homozygous.

Lotsy's definition of species plainly implies what he states explicitly elsewhere, viz. that, in his view, hybridisation

¹ A. L. and A. C. Hagedoorn: "The Relative Value of the Processes causing Evolution," 1921.

² Words within square brackets are mine.

³ *i.e.* Dalmatian hounds.

⁴ "Elemente der Exakten Erblchkeitslehre," p. 304.

followed by Mendelian segregation is the sole cause of the appearance of new forms. The logical application of this view to evolution as a whole leads to disconcerting conclusions, which, however, Lotsy does not hesitate to draw. We know that the "new" forms resulting from segregation after a cross are the expression not of the formation of new genes, but merely of the redistribution of pre-existing genes. If, therefore, hybridisation is the *only* source of new forms, then the primordial organisms (of which, on any such basis, there must have been at least one inter-fertile pair) must among them have possessed all the genes now existing in an immense array of combinations. Most biologists will probably find this hypothesis if anything less acceptable than that of separate creation.

It is interesting to note that Lotsy admits that Linnaean species have a real existence in a sense. They are, he says, "though themselves the vestiges of the results of a cross . . . kept distinct in nature by obstacles against free inter-crossing with other Linneons." Here we have introduced the important factor of *isolation*, which must be considered a little further.

Wagner¹ was apparently the first to attach prime importance to isolation as a factor in species production. More recently, this aspect of evolutionary theory has been very fully developed by A. L. and A. C. Hagedoorn.² These writers, arguing on an almost orthodox³ Mendelian basis, make great use of a concept which they term "potential variability." The "total potential variability" of an individual or group is measured by the number of genes for which that individual or group is not homozygous.⁴ The main agency causing reduction of the total potential variability, according to the Hagedoorns, is isolation (mechanical or physiological)—not selection, as Darwin supposed. Pedigree selection provides a striking illustration of this principle; a pure line has *no* potential

¹ "Über die Entstehung der Arten durch räumliche Sonderung," 1889. Wagner's own general conclusion is that species are immutable.

² *Loc. cit.*

³ The point in which they are not orthodox—the nature of genes—scarcely affects the present argument.

⁴ According to the view developed above (p. 323), the *absolute* value of the total potential variability is always unknown, though we may be able to distinguish between higher and lower *relative* values.

variability (apart from eventual mutation), and pure lines are obtained by mere isolation. In nature, though isolation of this complete type is rare, other factors tend to reduce the potential variability of populations. Owing to alternation of favourable and unfavourable conditions, any population will tend to start, at each generation, from a small proportion of the preceding generation. The environment thus acts as a "fractionating factor,"¹ quite apart from any question of adaptive selection. Purely statistical treatment of populations obscures this fractionating effect. If we assume that each individual in a population of strictly self-pollinated plants produces one offspring at each generation, it can be shown by simple arithmetical calculation that the total potential variability becomes reduced on the average by 50 per cent. at each generation. In the case of freely intercrossing populations, the original total potential variability theoretically should remain unchanged; but in practice the fractionating action of adverse periods is effective here also, and since heterozygotes throw homozygotes, whereas homozygotes cannot throw heterozygotes, there is actually a more or less rapid reduction of variability in every case. In short, "in the absence of crossing any group of plants or animals becomes pure [purer] for its genotype, and consequently for its phenotype *even without any selection*."

There is a considerable resemblance between the views of the Hagedoorns and those of Lotsy on the general question of evolution. Lotsy maintains that hybridisation is the sole cause of the production of new forms; the Hagedoorns believe that it is the main cause. Lotsy denies not only the occurrence but the possibility of mutation; the Hagedoorns admit that mutation occasionally takes place, but regard it as a factor of no appreciable importance in evolution. The attitude of the Hagedoorns towards the Linnaean species is, however, widely different from that of Lotsy. Lotsy, as we have seen, denies that Linneons are real species, and at most admits that they are groups produced by isolation (non-intercrossing) which simulate species. The Hagedoorns state their view as follows: "A species is a group of organisms so *situated* and so constituted that it tends automatically to reduce its total potential variability and which for this reason tends to become pure for one

¹ The term is mine.

specific type." Or again, "Species are realities, and they are stable, not changing. Further, we believe that those individuals which are seen to differ in one striking point from the members of a species in [among] which they live constitute a variety, whereas individuals differing in a group of characters from hitherto described species constitute a new species. In both cases, systematists have for a long period had an opinion differing radically from that of geneticists, and the later genetic evidence all points to the fact that the systematists have been right."

It may be noted in passing that the Hagedoorns' position involves them in difficulties in connection with the assessment of specific rank and as regards nomenclature. Let us consider the extreme case of a self-pollinated cultivated plant such as Wheat. According to the Hagedoorns each named sort, *e.g.* "Miracle" or "Red Fife," is a species because it is isolated, in cultivation, from intercrossing with other sorts. On the other hand, the whole assemblage of named sorts (probably over 2000) collectively known as *Triticum vulgare*, though a composite entity and not a true species, nevertheless *resembles* a cross-pollinated species inasmuch as it has its own total potential variability, which automatically tends to become gradually reduced. The Hagedoorns accordingly recommend a trinomial nomenclature for the "real" species in such cases, *e.g.* "*Triticum vulgare* Miracle," etc. The reasoning is not altogether clear; but there is undoubtedly something to be said on common-sense grounds for such a trinomial nomenclature. An alternative device is that used, *e.g.* in Aschersohn and Graebner's "Flora of Central Europe," in which many, at any rate, of the traditional Linnaean species are treated as "species-groups" ("Sammel-Arten") and analysed as far as possible into the lesser constant units.

Some of the flaws which mar Lotsy's argument recur in the Hagedoorns' exposition. But it is certainly interesting to find orthodox—or almost orthodox—Mendelians reverting, though by a somewhat circuitous path, to the traditional conception of the species which has always been maintained by the great majority of systematists. A fuller examination of the evidence upon which the Hagedoorns base their views as to the origin and nature of species would show that the remarkable distinctness and relative purity of local—*i.e.* spatially isolated—

racés (e.g. of *Mus rattus*) forms one of their strongest arguments. Facts of a similar kind occupy a prominent place in the most recent of the lines of investigation that bear upon the species problem, namely, that which has been developed during the past few years by Turesson,¹ under the name of "genecology." Turesson defines his position as follows: "The mass of genetically distinct forms which make up the Linnaean species [like most geneticists, he is clearly a Jordanian] do not distribute themselves indiscriminately over an area comprising different [i.e. ecologically different] types of localities, but on the contrary are found in nature to be grouped into different types, each confined to a definite habitat. Further, these 'ecotypes' do not originate through sporadic variation preserved by chance isolation; they are, on the contrary, to be considered as products arising through the sorting and controlling effect of the habitat factors upon the heterogeneous species population."

It will perhaps help us to understand this somewhat technical statement if we consider a concrete instance of the kind of facts which Turesson's culture experiments have revealed, namely, the case of *Solidago virgaurea*, Linn., as represented in Sweden.² Though not the most striking of Turesson's cases, this is a "fair sample," and has the further advantage that, in the original paper, the photographic illustrations bring out the main characteristics of the different races very clearly.

So far, *Solidago virgaurea* has been found to comprise four sets of ecotypes in Sweden. The names and most obvious differentiae of these types and the localities from which the experimental plants were taken are summarised in the table on the following page.

The types, especially the first three, are differentiated by a number of other characters, such as shape of leaf, form of inflorescence, etc.

The important point is that the differentiating features have been found to remain constant under cultivation. The stature of the dwarf plants (Alpine type) increased to a certain extent at first, but afterwards remained constant without ever having

¹ Papers in "Hereditas," 1923 onwards.

² Specimens from Germany, the Alps, and the Carpathians have also been taken into cultivation, but their behaviour has not yet been fully worked out.

Name of Type.	Principal Differentiae. ¹	Habitat of experimental Plants.
Alpine	Average height: less than 400 mm. Average width of ray florets: 2-12 mm. Regeneration of basal leaves: strong. Time of flowering: early June.	Finse, alt. 4000 ft.
Subalpine	Average height: 458 mm. Average width of ray florets: 2-35 mm. Regeneration of basal leaves: mostly strong. Time of flowering: middle June.	Åreskutan, alt. 2700 ft.
Lowland	Average height: 933 mm. Average width of ray florets: 1-91 mm. Regeneration of basal leaves: Weak. Time of flowering: late July.	Stenshuvud (woodland).
West Coast	Somewhat variable. Perhaps produced by intercrossing of two or more of the above types. (N.B.—The mountains closely approach the sea here.)	Bergen.

approached the stature of the taller types from other habitats.

Similar results have been obtained for all sorts of habitat types (including sand-dune and halophytic types) of a large number of species. Certain habitat types were found to lose their characteristic features in cultivation; these were evidently not ecotypes but mere modifications, similar to those studied by Bonnier.² The final and conclusive criterion, viz. that of breeding true to type, has been applied only in a few cases as yet, but the results, so far as they go, entirely support the view that the majority of habitat types are genetically

¹ In cultivation.

² Ann. Sc. Nat., Sér. 7, xx, 1895.

distinct. Independent confirmation of the existence of genealogical races is provided by observations incidentally recorded in Schröter's "*Pflanzenleben der Alpen*," concerning such races of *Dryas octopetala*, *Anthyllis vulneraria*, and *Pinus montana*.

As regards the bearing of genealogical investigations upon evolutionary theory and upon the species problem, Turesson makes it clear that he dissociates himself entirely from the Ultra-Mendelian attitude. For him the species question is in large measure an ecological problem, and the Linnaean species are ecological units of extraordinary importance. "Thanks to its genetically heterogeneous nature," he says, "the Linnaean species is able to cover a vast region by responding genotypically [*i.e.* not by mere modification] to a wide range of different habitats within the region. It is by studying the phenomena of these responses and their resulting products that we should gain a knowledge of the origin of the genealogical units." To gain a knowledge of the origin of the genealogical units is, of course, not the same thing as to apprehend the mode of origin of the *genetical* units, which, after all, is the central problem of evolution. In any case, we must await further development of the genealogical line of investigation before we can estimate its real significance to the geneticist and to the systematist. At the least, however, it promises to provide a salutary check upon the extravagances of the Ultra-Mendelian tendency. It compels the geneticist to face squarely the question of adaptation, which both Mendelians and Mutationists are inclined merely to shelve as incompatible with their particular theories.

In my own opinion, the implication that the Linnaean species may be a dynamic rather than a static unit is also to be welcomed, though most systematists will probably not agree with this view. Apart from the question of its ultimate value, the emergence—even if it be but for a time—of this fresh line of research is a development to be encouraged, because it provides a common meeting-ground for systematists, geneticists, and ecologists, three schools of workers who, if not professedly in separate camps, are at any rate prone to become so deeply immersed in their respective specialised branches of research as to be in danger of forgetting that they are all equally concerned in the solution of the age-long problem of the nature and origin of species.

When we come to consider how far the various lines of investigation and thought outlined in the second part of this paper (p. 320 onwards) help us to answer the fundamental questions (set forth on p. 320) concerning the nature and origin of the evolutionary units and the status of the Linnaean species, it must be confessed that their effect so far has been critical rather than constructive. It is quite clear from the work of the Jordanians (the term is used in a wide sense so as to include Johannsen and the empirical Pedigree Breeders, and, for this purpose, also De Vries and Turesson), that the Linnaean species is a composite entity and therefore not the *primary* unit of evolution. What—apart from the individual—does constitute that primary unit must still be regarded as doubtful. Intensive genetical analysis, on the lines followed by Erwin Baur in his work on *Antirrhinum*, of the several members of large genera, may help to throw light on this point, especially if carried out in conjunction with the experimental study of existing genecological types of the various species, and with renewed attempts to discover mutations within pure lines or to induce these by artificial means.

The question of the origin of the primary units is clearly bound up with that of their nature. Reasons have been given, on the one hand, for rejecting the view which regards the whole of evolution as a gigantic Mendelian experiment, and, on the other hand, for retaining the concept of mutation as at least a theoretically necessary element in the evolutionary process. It may be useful to recall that an essential feature of the mutation theory, as framed by De Vries himself, is the "all-roundness" of mutation, *i.e.* the assumption that the changes of structure which characterise the mutant are not orientated by the environment, but may take place in any direction and give rise in the first instance equally well to less well adapted as to better adapted forms. To a physiologist, there is something specially congenial about this aspect of the mutation hypothesis. The immediate (somatic) responses of the individual to stimulation are notoriously indirect; however adaptive and self-regulatory the final result may be, the actual connection between it and the initial stimulus is always very "roundabout," otherwise, indeed, the need for the concept of "stimulus and response" would not arise. On purely *a priori* grounds, therefore, it would seem reasonable to expect a non-

orientated origin for new forms arising through externally induced permanent changes in the hereditary substance. Admittedly it is difficult to account for adaptation on any basis of non-orientated variation. The strength of Darwin's theory in its final form lay in the fact that it avoided this difficulty very successfully. Adaptation is comparatively easy to understand, if we assume that modifications—which are orientated externally induced variations—are inherited. Unfortunately the evidence, so far as it goes, is all to the contrary effect. There is no escape from the hard facts of the pure line evidence. The claims of the Neo-Lamarckians, who believe that they have demonstrated the inheritance of modifications, cannot be entertained until proof has been given of heritable modification *within a population genetically pure for the characters which are supposed to have been modified*. This has never been done.

It is, of course, possible to argue that, while it is beyond doubt that pure lines remain constant over considerable experimental periods—some of Messrs. Vilmorin's pure lines of Wheat having been under observation for more than 50 generations,—it does not follow that they might not become permanently modified under the constant influence of some persistent factor of the environment in the course of secular time. There is not much comfort in a hypothesis which cannot be tested; and most biologists will assuredly not allow such a suggestion to deter them from planning further experimental attacks upon the apparently unshakable constancy of the pure line.

As regards the positive significance of the Linnaean species—which is the immediate question at issue here,—it is equally impossible to arrive at a final decision in the present state of our knowledge. All but the Neo-Lamarckians and the Ultra-Mendelians will probably admit that it is an evolutionary unit of a sort. In my own opinion, the view of Turesson, with its emphasis upon the ecological importance of the Linneon, has much to commend it—assuming, that is, that his experimental data prove to be generally valid. Perhaps the difficulties of this question have been needlessly accentuated by too great an insistence upon the identification of a single effective evolutionary unit. On any theory, the individual is actually the primary unit of evolution. But the multiple or composite

entities, such as pure lines or Linneons, are still units of a kind, and they are still subject as such to evolutionary influences in various ways. For instance, if a new species arises—no matter how—in the person of a single individual, the further fate of the species will certainly be affected by such a racial factor as the circumstance that the first individual may be imperfectly fertile or inter-sterile with some allied species and completely inter-fertile with others. Again the subsequent history of a whole Family might follow different lines, according as two portions of a Linneon became spatially separated from one another at a particular time, or as, on the contrary, the whole Linneon became shut off within a continuous area.

In this connection it may not be altogether out of place to draw an analogy with the conditions under which human society develops. Here also the primary unit is the individual ; but it is obvious that the several composite entities—the family, the nation, and even such highly artificial combinations as treaty-bound confederations or the League of Nations—are units which themselves are constantly undergoing an evolution that not only affects the whole structure of human society, but also reacts very sensibly upon the individual.

To return to solid ground. It has been my endeavour to show that the concept of the Linnaean species has not been destroyed by the victory of evolutionary ideas. Its significance has, indeed, been changed and rendered more complex and less easily definable. The systematist need not waver for a moment in his belief in its reality and practical value. At the same time he does not weaken his position if he recognises the existence of units within the Linneon. Little progress can be made with the formidable task of analysing Linnaean species until systematists, ecologists, and geneticists make up their minds to co-operate whole-heartedly. Biology has everything to gain, and none of its branches has anything to lose, by such a coalition.

REGENERATION FROM ROOTS OF ANCHUSA: ANCHUSA
ITALICA. By R. J. D. GRAHAM and L. B. STEWART.

(Read 18th November 1926.)

The practical horticulturalist recognises two main types of regeneration in raising plants from root cuttings. The new shoots arise either from the cut end as in Seakale or as lateral outgrowths, *e.g.* Horseradish, from the severed root. The genus *Anchusa* displays both types, the first in *A. italica*, the second in *A. officinalis*. Simon (1), discussing stem cuttings of *Populus*, states that the primary function of the callus on the apical end of a stem cutting is to give rise by differentiation to shoot formation. Priestley (2) extends this statement of Simon's to a generalisation that the origin of shoot initial in Dicotyledons is from the phellogen or superficial phellogen active near the cut surface. Taylor (3), however, found in *Acanthus montanus* that the shoot initials originated from the cambium in certain cases.

Anchusa italica propagates readily from root cuttings. The severed portions of the root about an inch in length are placed upright in the substratum so that the cut ends are level with the general surface. At a temperature of 75° F., buds are visible to the unaided eye on the fourth day after inserting the cuttings. Externally the upper end of the cutting shows a general browning of the cut surface with green buds showing in a ring immediately above the cambium.

Microscopic examination discloses a wide secondary cortex of parenchyma. This tissue is derived from the division of cells internal to the endodermis of the primary root (4). In vertical section the xylem vessels project slightly above the general level of the cut surface. This is due to shrinkage of the surrounding tissues. The cortical parenchyma contains large quantities of reducing sugar and a substance, probably Alkannin (5), which stains filter-paper brown. The wounded parenchyma cells form an irregular limiting layer over the cut surface. The cell walls give a typical cellulose reaction wherever they are uninjured. The radial wall adjacent to the injured cells also gives a faint cellulose reaction, but the wall is normally dark brown due to Alkannin—no septa

parallel to the cut surface have formed. Adjacent to the xylem, meristematic activity is evident in the cambium and this is the shoot initial. The meristem is, so far as observations go, independent of the callus or phellogen formation, and in certain cases the shoot initial is visible at a considerable distance from the injured end.

SUMMARY.

Shoot initials in root cuttings of *Anchusa italica* arise from the cambium of the root and are independent of the phellogen.

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THE SCOTTISH ALPINE BOTANICAL CLUB EXCURSION, 1925.
By Rev. J. J. MARSHALL LANG AIKEN, B.D.

(Read 9th December 1926.)

The Club met at Stranraer on 27th July, and found comfortable quarters in the King's Arms Hotel.

The morning of Tuesday 28th appeared none too propitious, yet the members set out for Logan, the ancestral home of Mr. Kenneth M'Douall, who had extended a cordial invitation to inspect the gardens and grounds. No sooner had they arrived than rain set in, and continued throughout the day. The far-famed gardens have assumed something of the nature of an experimental station; and, being practically immune from frost, they out-distance most parts of Scotland in the display of less hardy shrubs and plants. Exposed chiefly to the sweep of wind from the west, they have been protected by forest trees, high walls, and hedges, so that at no point can a complete view of them be obtained. A noteworthy feature in the treatment of rock plants is a terraced slope, made up of peat and faced with divots, in the interstices of which self-sown seeds find a congenial home. The salubrity of the climate may be judged of by such hot-house plants as *Cineraria stellata* and *Primula malacoides* flowering in the open border, as well as by the stately growth of Dracaenas and Blue Gums. Luxuriant development characterises most species, as, for example, *Rhododendron sino-grande*, a specimen of which bore a leaf 29½ inches in length in what was probably the fourth year after planting.

It would be an endless task to enumerate all the treasures which came under notice; but from their number may be selected the following, which for the most part were still in flower: *Lilium Brownii*, F. E. Br.; *L. philippinense*, Baker; *L. ochraceum*, Franch.; *L. Duchartrei*, Franch.; *L. Humboldtii*, Roezl et Leichtl.; *L. roseum*, Wall.; *Cordyline australis*, Hook. f.; *Hydrangea villosa*, Rehder; *Desfontainea spinosa*, Ruiz et Pav.; *Dierama pulcherrimum*, Baker; *Tigridia Pavonia*, Ker-Gawl. (in variety); *Cornus Nuttallii*, Audub.; *Lobelia Deckenii*, Hemsl.; *Cremanthodium reniforme*, Benth.; *Calceolaria integrifolia*, Murr.; *Romneya*

Coulteri, Harvey ; *Eucalyptus Globulus*, Labill. ; *Dicksonia antarctica*, Labill. ; *Lippia citriodora*, Kunth ; *Allium Wallichianum*, Steud. ; and *Nomocharis pardanthina*, Franch.

Having subscribed the Visitor's Book and partaken of their host's hospitality, the members bent their course towards Port Logan, threading their way through woodland studded with seedlings of *Anemone japonica*, and halting at the coast to view a salt-water pond in which Cod and Saith were so domesticated as to gulp shellfish from the hand, and suffer themselves to be stroked in the course of the meal. An examination of the shore was conducted under depressing conditions, the rain never ceasing and a westerly gale having risen. Among native plants gathered may be mentioned : *Malva sylvestris*, L. ; *Geranium sanguineum*, L. ; *Hydrocotyle vulgaris*, L. ; *Eryngium maritimum*, L. ; *Oenanthe Lachenalii*, Gmel. ; *Ligusticum scoticum*, L. ; *Symphytum officinale*, L. ; *Mertensia maritima*, Gray ; *Calystegia Soldanella*, Br. ; *Juncus Gerardi*, Lois. ; *Scirpus maritimus*, L. ; *Schoenus nigricans*, L. ; and *Carex extensa*, Good.

The Annual Business Meeting was held on the evening of the same day, when the officers of the Club were re-appointed, namely : President, the Very Rev. Dr. David Paul ; Vice-President, Professor W. Wright Smith, M.A. ; Interim Secretary and Treasurer, the Rev. J. J. M. L. Aiken, B.D. ; and Messrs. Alexander Cowan and T. Bennet Clark, and Sir Archibald Buchan Hepburn, Bart., were added to the Committee.

On the day following, the members were favoured with fair weather, and drove to the Mull of Galloway, following the same route through the Rhinns as on the previous day, and reaching the headland by way of Drummore. The atmosphere was hazy, but did not preclude a glimpse of the coasts of Ireland and of the Isle of Man. While affording pasturage, the promontory is bare of scrub, the cliffs rising abruptly to 200 and 300 feet. On its northern side it contracts into a narrow strip of land bounded by the East and West Tarbets, along which the shore may be reached. Before descending, a few of the party clambered down the rocks below the lighthouse, and intercepted a stranger in possession of a plant of Samphire, which he had gathered in ignorance of its name and rarity. Thereafter the party separated to examine the coast, and were

rewarded by the discovery of not a few notable seashore examples. So pleasing and profitable proved their search of these bays that, on their return journey, they halted at one or two others of the same character, with good results as the subjoined list may testify: *Lepidium Smithii*, Hook.; *Raphanus maritimus*, Sm.; *Arenaria peploides*, L.; *Spergularia rubra*, Presl.; *Vicia sylvatica*, L.; *Potentilla reptans*, L.; *Rosa spinosissima*, L.; *Parnassia palustris*, L.; *Sedum Telephium*, L.; *Lythrum Salicaria*, L.; *Apium nodiflorum*, R. f.; *Pimpinella saxifraga*, L.; *Crithmum maritimum*, L.; *Oenanthe Lachenalii*, Gmel.; *Daucus gummifer*, All.; *Eupatorium cannabinum*, L.; *Solidago Virgaurea*, L.; *Inula crithmoides*, L.; *Matricaria inodora* var. *maritima*, L.; *Carlina vulgaris*, L.; *Limonium vulgare*, Mill.; *Samolus Valerandi*, L.; *Verbascum Thapsus*, L.; *Bartsia Odontites*, Huds.; *Scutellaria galericulata*, L.; *Allium vineale*, L.; *Carex binervis*, Sm.; *C. distans*, L.; *C. extensa*, Good.; *C. Oederi*, Retz.; *Asplenium marinum*, L.; and *A. Adiantum-nigrum*, L. To these may be added, as in the Port Logan list, Lovage, Sea Lungwort, and Black Bog-rush.

In the course of their excursion members ascertained that the Peregrine Falcon (*Falco peregrinus*, Tunstall) nested on the cliffs as formerly, and themselves sighted the Raven (*Corvus corax*, L.), Kestrel (*Falco tinnunculus*, L.), Cormorant (*Phalacro corax carbo*, L.), Gannet (*Sula Bassana*, L.), Oyster Catcher (*Haematopus ostralegus*, L.), Red-shank (*Totanus calidris*, L.), Sheldrake (*Tadorna cornuta*, S. G. Gmelin), and Rock-dove (*Columba livia*, J. F. Gmelin).

Large part of the pleasure attending the visit to Lochinch, on the third day of the meeting, was due to the courtesy and personal direction of the Earl of Stair, who also entertained the members to lunch. The spacious grounds are crowned by the bulky ruins of Castle Kennedy, situated on high ground separating two extensive sheets of water, named the Black and White Lochs. A scheme of fortification, engineered by a former owner and still traceable in sunk avenues and terraces of lawn, lends distinction to them, while affording protection from the prevailing winds. Everywhere personal supervision and good forestry are manifest—the noble Conifers having been given ample space in which to develop their characteristic features. On account of a downpour of rain

it looked at first as if it would be necessary to remain indoors ; but ere noon the weather so improved that the party were able to make a fairly complete survey of the grounds, including the flower-garden, shrubberies, and woodland. The luxuriant growth of *Rhododendrons* again attested the normally mild state of the climate, many of them, in spite of the close proximity of basins of fresh water, doing as well as those noted farther south on the opening day of the meeting.

Among shrubs and forest trees which attracted attention the following may be named : *Callistemon salignus*, D.C. ; *Eucryphia cordifolia*, Cav. ; *E. pinnatifolia*, Gay ; *Arbutus menziesii*, Pursh. ; *Escallonia rubra*, Pers. ; *Hydrangea Nagasaki*, Hort. ; *Senecio Greyii*, Hook. f. ; *Lilium giganteum*, Wall. (10 feet 6 inches in height, with at least 19 seed vessels) ; *Rhododendron barbatum*, Wall. (in seed) ; *R. nobile*, Wall. ; *R. Thomsonii*, Hook. f. ; *Sequoia sempervirens*, Endl. ; *Araucaria imbricata*, Pav. (avenue of them, showing staminate and ovuliferous flowers) ; *Cryptomeria japonica*, D. Don ; *Abies amabilis*, Forbes ; *A. cephalonica*, Loud. ; *A. nobilis*, Lindl. ; *A. Webbiana*, Lindl. ; *Pinus insignis*, Doug. ; and *Tsuga Albertiana*, Sénéc.

On a sandy knoll adjoining the ramparts *Jasione montana*, L. made its appeal to the field botanist ; and in a field outside the policies a bountiful crop of New Zealand Flax (*Phormium tenax*) awaited consignment as an article of commerce. A motor-run along the shore of Loch Ryan brought the year's outing to an enjoyable close.

THE SCOTTISH ALPINE BOTANICAL CLUB EXCURSION, 1926.

By Rev. J. J. MARSHALL LANG AIKEN, B.D.

The members met at Middleton-in-Teesdale, Durham, on 19th July, and found quarters in Ye Cleveland Arms Hotel, which was ascertained to be the same as Cross Keys named in Report of Meeting 1884. For travellers by rail it is the only possible centre; but its distance from the best botanical ground of the district is somewhat of a drawback, the town itself affording no compensating objects of interest. There lie to the north on the main road from Alston two inns, the one at Langdon Beck and the other at High Force, which, if not specially commodious, provide readier access on foot to Widdy Bank and Cronkley Fells, and tempt travellers to shorten their journey from the north.

On the following day the party drove to Langdon Beck, a tributary of the Tees, and after inquiring of the innkeeper, who in his boyhood and under the direction of a local botanist had gathered plants on behalf of a gardener of Queen Victoria, commissioned to make a collection from the locality, they set out in the direction of Widdy Bank farm, which comprises a section of the "Sugar-loaf" limestone and the Falcon Clints, a series of abrupt rock-faces below the Cauldron Snout. Being few in number they could not cover the whole area and contented themselves with a survey of the Fell; but before making the ascent they sighted *Primula farinosa*, L., growing in profusion on marshy pasture-land, where *Gentiana verna*, L., was also established. The gathering of these made good their disappointment in regard to other rarities, notably *Arenaria uliginosa*, Schleich., which had also escaped the search of nine keen observers in the course of 1884 meeting. It is worthy of note that the statement in the Report of that year, "We were too late for most of the rare plants in Upper Teesdale," applied with equal force to the present expedition.

On their way back to Middleton the members halted at High Force to view the waterfall below the inn, and were delighted by the sight of the Tees in full flood rushing through a narrow gorge inaccessible to salmon, and plunging into a rock-bound chasm beneath, a combination of beauty and

grandeur little looked for by those who had followed its commonplace course throughout the day. Alongside the path leading to the river, and apparently preserved by those entrusted with the keeping of the verges, there bloomed in stately beauty *Cnicus heterophyllus*, Willd.

In addition to those already named, the following plants were gathered: *Sagina nodosa*, Fenzl; *Potentilla palustris*, Scop.; *Poterium officinale*, A. Gray; *Saxifraga aizoides*, L.; *Parnassia palustris*, L.; *Sedum villosum*, L.; *Peucedanum ostruthium*, Koch; *Gentiana campestris*, L.; *Menyanthes trifoliata*, L.; *Bartsia alpina*, L.; *Listera ovata*, Br.; *Orchis incarnata*, L.; *Scirpus compressus*, Pers.; *Kobresia caricina*, Willd.; *Blechnum spicant*, With.; *Cystopteris fragilis*, Bernh.; *Phegopteris polypodioides*, Fée; *P. Dryopteris*, Fée; *Lycopodium clavatum*, L.; *L. Selago*, L.; and *Selaginella selaginoides*, Gray.

Rain fell during the night, and on the morning of 21st, when a start was made for Cronkley Fell, the direction of the wind and the aspect of the heavens foreboded ill. Inquiry having been made regarding the proper route, *that* by the first gate on the left beyond the Wesleyan Chapel was selected, though without any clear understanding whether a right-of-way existed. Alighting at Winch Bridge, the members spent some time on the Durham bank of the Tees in the belief that the Spring Gentian had been gathered there, but had not the good fortune to find it. In the shade of the trees above the rocky channel of the river they gleaned *Crepis paludosa*, Moench.; *Leontodon hispidum*, L.; *Carex muricata*, L.; *C. leporina*, L.; and *C. fulva*, Host.

Continuing the drive by High Force and the chapel they encountered such a storm of rain that they were compelled to delay their journey till after midday, and so greatly curtailed the time available for hill-climbing. The Tees was now a seething flood, the pastures were sodden, and the hillsides streaked with miniature cascades; yet, with the exception of an occasional blast, the afternoon proved favourable for their purpose. The ascent of the Fell was begun from the north along a watercourse on whose banks flourished *Asplenium viride*, Huds. Following it to its source on Cronkley Scaurs, the small party noted *Rubus chamaemorus*, L., amongst the heather, and *Thalictrum alpinum*, L., upon the limestone;

and heading south over undulating ground they struck the "Sugar-loaf" outcrops, which form the distinguishing feature of the Fell. Powdered into granules they furnished a happy foothold for *Arenaria verna*, L., and *Dryas octopetala*, L., which thrived exceedingly, though in an undersized form. *Helianthemum Chamaecistus*, Mill., covered a considerable area, but the Hoary variety (*H. canum*, Baumg.) escaped notice. No trace of *Hippocrepis comosa*, L., reported from the summit, was found. The party was greatly handicapped by their insignificant number and the brief space of time at their disposal.

The pastures at the base of the Fell were notable for the abundance of *Poterium officinale*, A. Gray, and the exceptionally large and varied flowers of *Viola lutea* var. *amoena*, Sym. As haymaking was only begun, these were seen at their best. Other less common plants included: *Galium boreale*, L.; *Primula farinosa*, L.; and *Melampyrum pratense* var. *montanum*, Johnst.

FUNGI AS AN INTERNATIONAL PROBLEM. By GLENN
GARDNER HAHN, B.Sc., M.Sc.

(Read 20th January 1927.)

In a consideration of that very large problem which has to do with the introduction of fungi from one country into another, the mycologist and botanist, together with the phytopathologist, are frequently confronted with a complicated problem, which has both its economic aspects and its purely scientific ones as well. Economic situations resulting as a consequence of the international distribution of fungi are often of such magnitude that they may to a large extent, and in a very direct fashion, strongly affect not only the agricultural resources of a particular nation or nations, but also the very lives and happiness of the people themselves. While the economic phases of the problem of introduced fungi are being much stressed these days of intensive and extensive plant culture, the fact remains that extremely valuable data of a purely scientific nature have been derived from situations wherein the native flora or agricultural crops of a country are exposed to the parasitic attack of foreign fungus intruders.

It is an old adage that it is an ill wind that blows nobody any good, and it is truly applicable in this case; for while a nation may suffer materially to a large extent by the inroads of foreign pests, there is much that has been gained by scientific investigation as the result of the study of these plant emergencies. Such derived information concerning fungi has greatly increased our intensive knowledge of them as regards their morphology, their physiology, and their distribution. At the same time there has been an increased stimulation in experimentation in the fields of genetics, biochemistry, and plant physiology, especially with regard to that very important problem which has to do with disease resistance in plants.

So far as America is concerned, that country has been the scene of heavy encounters between the native flora and the agricultural crops and foreign fungal pests. Nor should one neglect to mention here the large number of insect enemies which have come to that country from abroad. It is generally

acknowledged by phytopathologists both in America and in Europe, who are conversant with conditions on both sides of the Atlantic, that diseases of economic plants manifest themselves and flourish much more virulently on the American continent than they do in Europe. Why this is true is very difficult to state in exact terms, for in a consideration of disease there are so very many factors which must be examined. In an estimation of the American situation, however, one must consider a number of things, *e.g.* the great range in climate there, the great diversity of native plants, and the enormous areas of practically pure cultures of economic plants. In spite of their extreme liability to excessive damage from without, the flora of America was for a long period unprotected by any plant quarantine laws, instituted for the purpose of regulating foreign importation. It was not until 1912 that any such laws were put into effect—which was two years after Canada had taken the step to protect her own great agricultural resources.

Plant quarantine laws originated in America only with great difficulty and duress. Probably the one great circumstance more than any other which brought concerted action on the part of that nation for the protection of the flora and crops of the country, was the serious and devastating chestnut blight caused by *Endothia parasitica*, (Murr.) A. et A.—a disease caused by a fungus introduced from the Orient, and one outstanding in the annals of the history of plant diseases.

The chestnut blight disease has practically exterminated the native American chestnut (*Castanea dentata*, Borkh.) as a botanical species. As a commercial species the fate of this forest tree is also definitely sealed (2). From 1904 to 1911 the Oriental fungus cost the United States \$25,000,000 (£5,000,000). With the extermination of this chestnut species the situation becomes particularly aggravated, for the American chestnut supplied 50 per cent. of that country's production of tannin used in the manufacture of leather.

From the standpoint of pure science the chestnut blight emergency resulted in the scientific investigation of the causal organism, with the result that this particular fungus is perhaps as completely investigated as few other fungi are in the world to-day. *Endothia parasitica* had to be definitely proven dissimilar from the native species of the same genus,

to which it was apparently closely related morphologically (4). This problem was enormous. In a critical examination of all the species of *Endothia* obtainable, 600 collections and 4000 cultures were studied, which proved beyond doubt the parasite to be distinct from the native organisms, both morphologically and physiologically. The definite discovery of the parasite in China by the plant explorer Meyer, in 1913, and later in Japan, also definitely aided in settling this question of identity.

America is now facing the problem of evolving resistant chestnut stock suitable for forest purposes; for, since direct control of the disease is impossible, recourse must be had to disease-resistant stock. Upon all the true American chestnuts the chestnut blight organism is actively parasitic. The European chestnut is also readily susceptible to the disease. On the other hand, the Oriental chestnuts, *Castanea mollissima*, the hairy Chinese chestnut, and *C. japonica*, the Japanese chestnut, are more or less naturally resistant both in America, under controlled conditions, and in their native habitat. It is hoped, with the introductions of these Asiatic forms, to develop a resistant strain of American chestnut by crosses with the native forms, or by the discovery of resistant plants themselves among the native stock.

The blister rust of Weymouth pine (*Pinus Strobus*, L.) is another serious forest disease, caused by a fungus (*Cronartium ribicola*, Fisch.) which has ravaged the five-needle or white pines of both Europe and America. This fungus has been actually known in Europe for more than sixty-five years (3), (7), where it probably came from some far-distant Siberian source. This view is held by Dr. Tubeuf of the University of Munich, and by Dr. Spaulding of the United States Department of Agriculture.

In Siberia it probably originated on the Siberian form of *Pinus Cembra*, L., and, migrating to Europe, became particularly virulent on the exotic five-needle pines it found there. All the five-needle pines are susceptible except the Himalayan pine (*P. excelsa*, Wall.), the Balkan pine (*P. peuce*, Grisebach), and the Alpine form of *P. Cembra*, which are more or less resistant. So persistently did the blister rust spread in Great Britain, that within a period of less than twenty years it became thoroughly established. Professor Somerville stated

in 1909 (5) that the future for Weymouth pine was hopeless because of this rust.

In America the disease was introduced upon diseased nursery stock from Europe (3), (6), and is known to have been present there as early as 1898. By 1916 it was widely distributed in New England on *Pinus Strobus*. Very recently the blister rust has also been found on the Pacific coast in the State of Washington and in British Columbia. This situation is extremely serious for the United States; for there are seven white pine species in the West, and that nation's greatest white pine resources are centred in the western white and sugar pine forests of *P. monticola*, Dougl., and *P. Lambertiana*, Dougl. According to the estimate of the United States Forest Service, this white pine timber is worth something like \$228,400,000 (£45,680,000). Yet these vast resources are now subject to the insidious disease from Siberia. Control measures are being enforced. This all means the expenditure of money and labour.

Methods of control have been successfully worked out by the United States Department of Agriculture, which consist in the extermination of the European black currant, *Ribes nigrum*. L., arch-enemy of the Weymouth pine. It has been found in the investigation of the disease in the eastern United States, that Weymouth pines are subject to little or no damage from the rust if no black currants are left growing within a mile, and no other currant or gooseberry bushes within 900 feet. By the elimination of this alternate plant host, upon which the rust depends for its complete life cycle, the very valuable white pine may be preserved. America must preserve her great forest resources and species, which she considers highly. Europe, on the other hand, popularly considers black currants and gooseberries more highly than the exotic white pines, hence they are being supplanted by such species as Douglas fir, Sitka spruce, or Japanese larch.

The fact that certain fungi are able to propagate over a wide geographical area is a very important phase of the problem of introduced fungi. In the United States the chestnut blight organism thrives over a wide range of territory and environmental conditions. The same situation holds true for the Siberian intruder on the European and North American white pines. All that was apparently needed in the case of

the blister rust of white pine were the two alternate hosts—pine and currant, and the rust fungus. Disease accomplished the rest.

The case just mentioned concerns a heteroecious rust—that is, one which is dependent on an alternate host for the completion of its full life-history. Control is therefore somewhat simplified by the elimination of one of the hosts to preserve the other. However, in the case of autoecious rusts, which are only dependent on one host for their continued existence, the problem is necessarily much more difficult. In the case of a pine autoecious rust the fungus is able to spread directly from pine to pine. Only very recently such a fungus has appeared near the little town of Woodgate in the State of New York, United States of America. This rust is a mystery, in that it bears no direct resemblance to any known rust anywhere else in the world. Curiously enough, it occurs only on Scots pine (*Pinus sylvestris*, L.), which is used in America as a tree on sandy stretches, where it is particularly adapted for tying down blowing-soil. Until this rust fungus can be determined and its source located, the fungus is for convenience known as the Woodgate rust (1), (9). If this rust is an introduction, it must be proven so. At the same time, its relationship with other rusts already occurring in the country must be very carefully worked out. The possibility of its spread to other pines, especially the commercial species, must be carefully watched. The Woodgate rust is a gall type of peridermium, apparently quite distinct from the *Peridermium pini*, or bladder rust, which occurs on the Scots pine in the British Isles. The Woodgate rust is now confronting American mycologists and foresters with all the problems associated with a probably introduced parasite.

The plant diseases due to introduced fungi which I have been relating are by choice diseases of forest trees. The history of plant disease contains many examples of exceptional and outstanding diseases which have arisen in various countries as the direct result of the introduction of foreign fungi. Diseases due to introduced insects have also seriously aggravated this situation of imported foreign pests. In Great Britain the Douglas fir aphid (*Chermes cooleyi*, Gill.) from North America is now threatening the Douglas fir, and the silver fir aphid (*Dreyfusia nuesslini*, Börner) from the continent may

cause the abandonment of the growing of *Abies pectinata*, DC., as a forest tree according to the opinion of British entomologists.

So far only the introduced fungus species has been considered. Another aspect of the internationality of fungi is the consideration of physiological strains or races of the same species. Two sessions ago, Mr. J. S. L. Waldie brought to the attention of this Society the serious damage caused by the root-rot fungus, *Fomes annosus* (Fr.) Cke. This fungus, as he pointed out, is known to attack Douglas fir, Scots pine, larch, Norway spruce, Weymouth pine, beech—in fact a long list of both hard and soft woods. In America, on the contrary, while present this species apparently does little damage. Should the European strain of *F. annosus* be introduced into the great Douglas fir region of the Pacific North-West, it might prove highly virulent in its new habitat, quite in contradistinction to the strain or strains of the same species which already exist there, but which are not of any great importance.

Strains of the European organism, *Phomopsis Pseudotsugae*, Wilson, to which the Phomopsis disease of Douglas fir, *Pseudotsuga Douglasii*, Carr. (8), has been attributed, are now being investigated by Dr. Malcolm Wilson and the author to determine their comparative parasitism under conditions of artificial inoculation. This fungus of the Douglas fir has been recently described by Dr. Wilson. In all probability the fungus belongs to the Old World, and has remained unrecognised on other coniferous hosts until recently, when it was discovered on the introduced exotic from North America. So far as is known this fungus is not present in the United States, where it may be considered a potential danger to the enormous stands of Douglas fir which constitute 25 per cent. of the standing timber of that country. Preliminary inoculation experiments with *P. Pseudotsugae*, carried out in the vicinity of Edinburgh, have given a high percentage of positive results. They are here reported for the first time.

A striking example of the reaction of fungus strains with regard to parasitism in a new environment is the very recent British case of *Rhabdocline Pseudotsugae*, Syd. This fungus, which causes a needle cast of Douglas fir, has very probably been imported from North America, and is now seriously threatening the blue and intermediate forms of Douglas fir.

Fortunately, so far the valuable green form has been exempt from attack, but the effect on the other forms of Douglas fir is much more drastic than that encountered in America.

In a consideration of financial loss due to introduced fungus and insect pests, not only in America but in Britain and on the continent as well, the situation becomes very convincing that a nation's flora and agricultural crops must be protected at all costs. To this end a comprehensive quarantine is the only safeguard against foreign plant, as well as insect, diseases. Adequate plant disease survey also greatly augments the work of plant quarantine; for not only are the diseases of the particular country taken stock of, but there must also be a recognition and study of foreign diseases which may be potentially dangerous to the agriculture and forestry of a country where such diseases do not occur. In addition to these there are also those diseases still unknown to science which must be most carefully guarded against. Regulation of the spread and distribution of plant diseases within the country itself must be also enforced. Any weakening of policy with regard to quarantine laws, or lethargy to react when known dangers are imminent, may result in increased future expenditures of money and labour for control, as well as possible large financial loss.

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STUDIES IN WILD RICE—ORYZA SATIVA, LINN.

By R. J. D. GRAHAM, M.A., D.Sc.

(Read 17th March 1927.)

Wild forms of rice differ from the cultivated forms in two chief characteristics. The grains in the wild forms fall while still green (1), and though they fall into water or mud they do not germinate until the succeeding monsoon (2). It is in connection with the delayed germination of wild rice that the following experiments were carried out.

Germination Tests.—Comparative germination tests were carried out in March, 1921, of pure lines of cultivated rices and of grain from single ears of wild rice, both having been harvested in 1920. The tests were run in Petri dishes, the grains being placed on crochet mats. The dishes were placed in a germinator at 28° C. In all cases the cultivated rices germinated within twenty-four hours whereas the wild rices showed no germination over a period of at least forty-eight hours, nor within a similar period on re-soaking after drying. Removal of the husks made no difference to the result except that an occasional wild rice grain germinated in twenty-four hours. Scratching the pericarp over the embryo secured germination in the wild rice in twenty-four hours, indicating that the occasional germinating grain was the result of injury to the pericarp during removal of the husk. Under the conditions of the experiment a copious development of hairs was obtained on the coleorhiza in contrast to the finding of Klebs (3).

Water Intake.—Experiments were carried out to determine the water intake of wild and of cultivated rices. Ten or twenty grains of each were submerged in Petri dishes containing tap water and incubated at 28° C. Hourly weighings, after drying with filter-paper, were carried out. Comparing the data there is a higher water intake in the cultivated than in the wild forms. The mean of the percentage increase in weight over the dry weight for six pure lines of cultivated rice after twelve hours was 19.22 per cent., while seven wild forms gave a mean of 15.59, showing a difference of 3.63 with a standard error of ± 0.329 . At twenty-four hours, when germination had started

in the cultivated rices, the mean was 27.10 per cent. and 20.56 per cent., showing a difference of 6.54 per cent., with a standard error of ± 1.48 . Removal of the husk permitted a quicker entry of water. After six hours both the cultivated and wild rices showed an increase of 20 per cent., but in the succeeding period to twenty-four hours the wild rices only increased to a mean of 23.56 per cent., while the cultivated rices showed a mean of 32.77 per cent. The difference in water intake, though distinctive for the two forms of rice, is not the cause of the delayed germination. Figures showing the water intake of germinating wild rice, germination produced either artificially by scratching the pericarp over the embryo or in germination tests in 1927 when the wild rice germinated within twenty-four hours, give an average of 24.12 per cent.

DISCUSSION.

Crocker and Davis (4), discussing as regards seed and fruit coat the causes of delayed germination, mention the absolute exclusion of water, limited degree of swelling of embryo, reduction of oxygen supply below the minimum necessary for germination. A possible alternative cause might be mechanical hindrance to the exit of the embryo. The facts in wild rice fit into the third class, *viz.*, limitation of oxygen reaching the embryo, as microscopic examination of the pericarp over the embryo discloses a structure similar to that described by Harz (5) with no anatomical peculiarities.

CONCLUSION.

Wild and cultivated forms of rice differ in the amount of water taken up during germination and the difference is significant, being greater in cultivated forms.

The delayed germination in wild rice is not due to the smaller water intake, nor to anatomical difference in the pericarp over the embryo, but appears to be due to a limited oxygen supply reaching the embryo, until the pericarp is ruptured artificially by scratching or naturally by drying.

In conclusion I desire to thank Mr. S. C. Roy, L.Agr. Assist. Botanist to the Central Provinces Government, India, for supplying me with rice grains, and Mr. James Todd Johnstone,

M.A., B.Sc., Royal Botanic Garden, Edinburgh, for assistance in the statistical part of the paper.

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OBSERVATIONS ON THE STRUCTURE OF ZYGOPHYLLUM
FABAGO, LINN. By LILY M. CUNNINGHAM, B.Sc.

(Read 28th April 1927.)

Zygophyllum Fabago is a member of the family Zygophyllaceae, a family of erect, perennial herbs, shrubs, or small trees with stipulate, fleshy and opposite leaves. The family is allied to the Rutaceae.

The Zygophyllaceae and the Thymeliaceae are the only two natural families whose members are poisonous to camels. These animals never touch such plants unless driven by excessive hunger (1, p. 19). *Zygophyllum Fabago*, however, is a valuable medicinal plant in the east (1, pp. 193 and 226).

The plant is a native of the arid parts of the Mediterranean region and of the Orient, where it extends throughout Asia Minor, Palestine, Mesopotamia, Babylonia, Persia and into Afghanistan and Baluchistan. North of the Orient it extends throughout the Caucasus region, the depressed deserts of the Caspian shores, Turkestan, and the steppes of South Russia into Dzungaria. In short, the distribution corresponds roughly to the temperate and sub-tropical grasslands, semi-deserts and desert regions of the Mediterranean and the Orient, eastwards. It is also common throughout these regions as a weed, where it grows in the debris of old buildings (1, p. 226). It was introduced into this country in 1596 (6).

The habit is that of a glabrous, erect shrub, attaining a height of about two feet when planted in rich soil in this country. Grown under such favourable conditions it is noticeably sturdier than herbarium specimens collected in the east. In the Royal Botanic Garden, Edinburgh, where it grows in an open, sunny position, it dies down towards the end of October and begins to send up new shoots in February. Here it flowered in the beginning of October 1926. In Palestine, which is approximately the centre of its distribution, it flowers in spring and early summer.

GENERAL MORPHOLOGY.

The plant has a characteristic habit of growth. Usually only one of the opposite, axillary buds develops, thus giving

an appearance of dichasial branching. In transverse sections through the node, where one axillary bud has become differentiated into axis and leaves, the opposite bud is arrested in development before any differentiation of the meristem is noticeable. This behaviour is not absolutely constant, however, as at some nodes both buds develop equally.

The shape of the stem is peculiar in the younger parts, being rounded on one side and flattened on the opposite one. Correlated, perhaps, with this morphological distinction, the vascular system is better developed on the rounded side. This is especially noticeable in the region of the node, where the nodal anatomical changes are found to occur at a slightly higher level on the flattened side of the stem. The older part of the stem is more or less round with no flattening.

Peculiar glands occur over the entire surface of the plant, whose function apparently is to discharge mucilage.

The discharge of these glands is very obvious as a yellowish precipitate, which occurs at the position of the glands all over stem and leaves, when the plant is soaked in spirit for a time. The glands are most abundant on the inner surfaces of the adpressed stipules, as seen in transverse sections of young nodes. This suggests a protective function for the glandular discharge from these organs. Moreover, the stipules in *Z. Fabago*, with their broad sheathing bases and by their inter-petiolar position, are particularly well designed to protect the axillary buds.

The stipules show a gradual transition of form as the stem is ascended from one simple undivided lobe placed in an inter-petiolar position to a form where the median indentation gives a 2-lobed appearance and finally to a form with a deep median indentation.

INTERNODAL ANATOMY.

Throughout the length of the internodes there are strands of woody fibres formed of bundles of fibrous cells, which occur between the cortex and the bast. Solereder (7, vol. i, p. 167) says they are formed of isolated groups of primary bast fibres and, according to him, secondary bast fibres are wanting. It is interesting to note that these fibres terminate just below the node, while those of the next internode commence above it. The node itself is strengthened by stone-cells or sclerides,

which are present in abundance throughout the cortical and stelar parenchyma of the node; they are, however, entirely absent from the internodal tissues. The sclerides are regular in outline and more or less spherical, not elongated. The distribution of these isolated, thickened cells throughout the node gives a compact rigidity to the whole.

The vascular system of the internode takes the form of a complete cylinder of xylem surrounded externally by phloem. The cylinder is flattened on one side, corresponding with the configuration of the young stem, and on that side is not so well developed as on the convex side (fig. 1, i). Transverse sections of internodes at various stages of development were examined, and the only difference noted was that the cylinder was thinner in the young internodes, there being a greater proportion of conducting tissue to parenchyma as the stem grows older. The fibrous strands, as would be expected, are not fully developed in the younger internodes. The pith is composed of large, thin-walled cells, which serve to store water (7, vol. ii, p. 850).

NODAL ANATOMY.

The anatomy of the node is somewhat complex, owing to a considerable disintegration of the vascular tissue of the axis. The opposite leaves, axillary buds, and a pair of inter-petiolar stipules at each side of the stem all arise about the same level and, consequently, the stelar changes are considerably telescoped. Tracing the vascular system from below upwards the first change, as the node is approached, is the departure of a narrow part of the vascular cylinder from the middle of the convex side (fig. 1, ii and iii). When this strand has ascended about one or two millimetres and has moved outwards from the main cylinder, it divides into two forks, which extend laterally to form horizontal girdles, each of which passes round about a quarter of the stem (fig. 1, iv and v). Meanwhile a similar change has commenced on the opposite flattened side of the stem and the central cylinder soon resolves itself into eight components. Two of these, placed opposite each other in the transverse plane, constitute the petiolar supply (fig. 1, iv). As each petiolar strand passes into the leaf-base it is joined by the girdle components, first on the rounded side and later,

at a slightly higher level, on the flattened side (fig. 1, v and vi). The remaining four components of the central cylinder

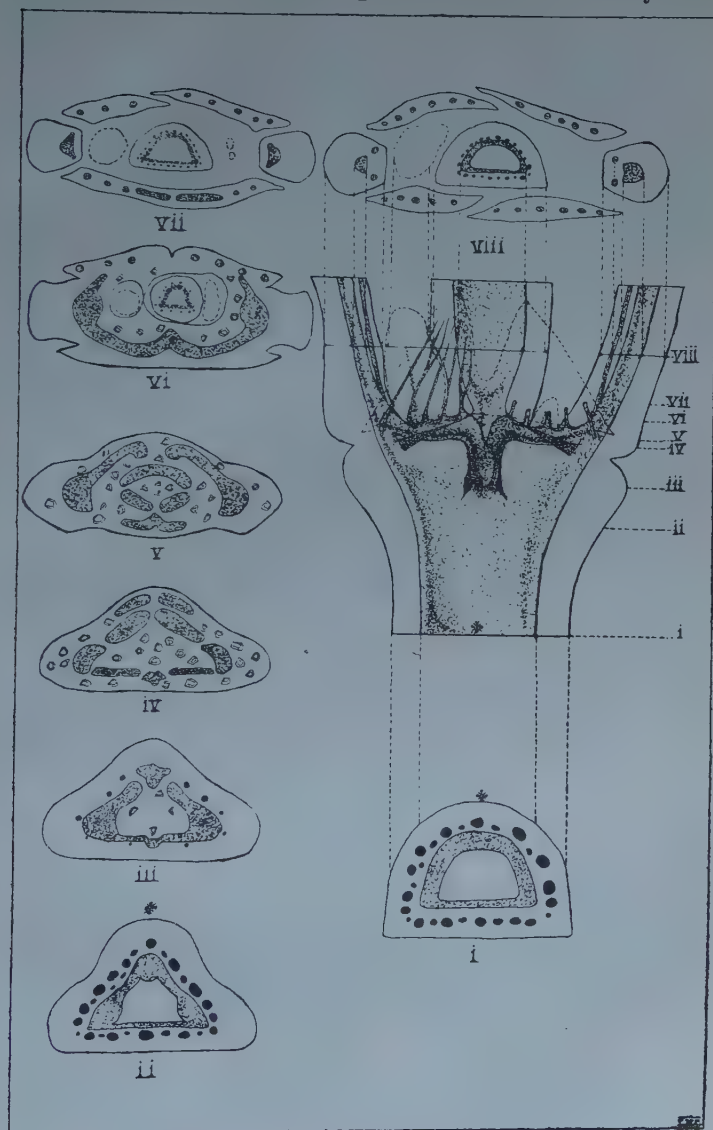


FIG. 1.—Vascular anatomy of the node ($\times 6$).

fuse laterally to form the continuation of the stele in the main axis (fig. 1, iv, v, and vi).

Stipular Supply.—The presence of the transverse girdle seems to be primarily correlated with the vascular supply to the inter-petiolar stipules and from each quadrant of the girdle there arise about half a dozen small strands, which ascend into each stipule and anastomose throughout its tissues. The girdle, together with the presence of the sclerides, seems also to be of some use in older stems as a means of mechanical support in a region deprived of much of its axial fibro-vascular tissue. This added strength of the nodal regions was suggested during the preparation of a model.

Other Examples of Girdle Systems.—On examining *Pelargonium*, which has alternate leaves and large petiolar stipules, it was found that here each leaf is provided with half a girdle, which encircles the vascular cylinder on the side which the leaf occupies. This is obviously another case where the girdle formation is in connection with stipular supply. De Bary (2, p. 240) describes a similar arrangement in connection with the stipular supply of *Lathyrus Aphaca* and *L. Pseudaphaca*. The same author, however, also describes a girdle arrangement in *Osbeckia canescens* (2, p. 259), whose function it is to provide for communication between the cortical and ring bundles of the axis.

THE LEAF.

At the end of the petiole are two leaflets, laterally placed, with a mucronate point between them. This mucronate point appears as a third, small, terminal leaflet in juvenile leaves, while in some adult leaves it varies in form between a narrow leaflet and a mucronate point. These variations appear to be of a recapitulatory character, indicating the various stages of modification of the terminal leaflet and, to a certain extent, a lingering of its normal and ancestral condition. Recapitulation is also suggested in the gradual variation of the form of the stipules as the stem is ascended.

The petiole is approximately the same length as the lamina. It has two lateral flaps extending along its length and projecting obliquely upwards, forming, medianly, a V-shaped gutter on the adaxial side of the petiole. These terminate about a millimetre in front of the lamina.

The lamina and petiole are soft and semi-succulent and the lamina is thicker than that of ordinary plants, even when the plant is growing in a place where it gets plenty of water. The

epidermis is decidedly glossy, correlated, probably, with the intensity of light against which the plant has to protect itself owing to its exposed habitat.

Petiolar Supply.—The supply to the petiole is a single segment from the central cylinder reinforced from the girdle. In the leaf-base this assumes a cylindrical form and resolves itself into three components, two of which are small and move into a lateral position on the adaxial side of the petiole to supply the petiolar flaps. All three vascular strands are invested by fibres, and there are, in addition, several independent fibrous strands, which ascend the petiole.

Just below the base of the lamina the petiolar flaps terminate, and the single vascular strand of each moves inwards and joins the main vascular cylinder laterally and adaxially. Almost immediately after the resolution of the three cylinders into one, radial, parenchymatous strips appear, breaking up the cylinder into two portions, a large semi-circular one abaxially, embracing a smaller adaxial one. As the lamina is approached, the single broken cylinder resolves itself into two similar broken cylinders by a median split extending in an adaxial-abaxial direction. These two strands form the midribs of the two asymmetrical leaflets. The lateral veins come off from the parenchymatous gaps. The broken cylinder type of strand persists throughout the lamina, and is difficult of interpretation there until the vascular system of the proximal petiolar region has been examined in detail.

The phloem is well developed throughout the leaf. The fact that it forms a relatively wide band around the xylem and that the protoxylem is endarch in both adaxial and abaxial portions of the strand, shows that the whole strand is merely an interrupted cylinder of vascular elements. The margins of the adaxial strand may curl round adaxially so that in the curled-round portion the phloem comes to lie opposed to the phloem of the original adaxial strand and the protoxylem appears exarch.

Briefly, then, in *Zygophyllum Fabago* the central cylinder breaks up at the node into eight portions, two of which constitute a direct petiolar supply, two form a girdle system supplying the stipules and connecting with the petiolar strands, and the remaining four join up to form the cylinder of the next internode.

FLORAL STRUCTURE.

The flowers are borne singly or, more rarely, on two-flowered peduncles. They are about ten millimetres long and about the same in width when fully developed (fig. 2, i). The calyx more or less invests the corolla. The upper, exposed part of the corolla is of a dull grey colour, the lower part being of a

FIG. 2.—($\times 7$).

dull brownish-red tint. The anthers and filaments are of the same colour.

The sepals, five in number, alternate with the petals, the odd petal being posterior. They are green and persistent, and enclose the whole flower up till the time of dehiscence of the stamens. There are five clawed petals, which Boissier (3) describes as cuneate and retuse. In the *Zygophyllaceae*, according to Goebel (5), the ten stamens are obdiplostemonous: "five stamens being subsequently interposed between the five calycine stamens, which were first formed." This condition,

Goebel maintains, is dependent upon the space left by the growing torus. At the base of each stamen there is a fimbriated papillose scale, which lengthens as the flower matures, but which is quite short in the bud. These scales are situated on the adaxial side of the stamen, and directed towards the gynaecium they form a chamber investing the latter. This arrangement suggests the storage of nectar, since, at the time, of anther dehiscence, the chamber is usually full of a viscous fluid, apparently secreted by the toral disc and the base of the scales themselves. These staminal scales are a diagnostic feature of the family, and it would seem that they are merely expansions of the disc, which is a characteristic feature of the Geraniales. The gynaecium is 5-angular and slightly ridged, broadly confluent with the torus at the base and tapering towards the style, which is typically bent upon itself in the bud. The ovary is 5-chambered, the chambers alternating with the sepals. There are numerous ovules borne in two rows in each chamber, the placentation being axile. The funicles are recurved.

The flower shows a decided tendency towards zygomorphy in a median plane. This is most marked in the torus and base of the ovary. The torus is depressed on the anterior side so that the ring of attachment of sepals, petals, and stamens slopes downwards from the posterior to the anterior side of the flower (fig. 2, ii). From this it follows that the floral parts on the anterior side are joined to the torus at a lower level than those placed posteriorly. These features are seen in a series of transverse sections of the flower (fig. 3, i-vii).

At the base of the flower (fig. 3, i), the axis is supplied with a central core of conducting tissue surrounded by a ring of five vascular strands, each of which divides just below the point of origin of the sepals to form a ring of ten bundles (fig. 3, ii). From these are derived the strands which supply the sepals (fig. 3, ii and iii, where the calycine strands are enclosed in dotted lines). The ten strands continue upwards and the branching system derived from them constitutes the supply to petals and stamens. The axial core first resolves itself into a cylinder and later becomes pentagonal in outline, finally disintegrating into five strands, which pass into the carpels where they undergo further branching.

The first sepal to be liberated from the torus is an

antero-lateral one, as seen in fig. 3, iii and iv, and on this side of the flower two petals and one stamen are free from the torus before any of the remaining four sepals. It is to



FIG. 3.—Sections of flower.

this elevation of toral tissue towards the posterior side that the slight zygomorphy of the flower is primarily due, rather than to marked differences in development of the floral parts. At the time of anthesis, the stamens are approximately of equal length, although the three posterior calycine stamens.

are slightly longer than the others. According to McLean Thompson (8), zygomorphy is due to irregularities during the phase of extension of the flower parts, but in the example under discussion it is difficult to suggest a cause. The close approximation of the young flower bud to the more rigid axis might result in unequal expansion of the toral tissue and lead to irregularities in its final expression. Zygophyllum certainly presents an example of incipient zygomorphy in which little but the torus of the flower is involved. It would seem to belong to a different category from those cases where pronounced zygomorphy of the flower is apparently related to advanced entomophily.

In conclusion, the writer desires to express her indebtedness to Mr. J. R. Matthews for suggesting this investigation, and for advice and assistance during its progress.

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ON THE DISTRIBUTION OF THE LARGER BROWN ALGAE IN
ABERDEENSHIRE ESTUARIES. By E. H. CHATER. (With
Pls. XIII, XIV.)

(Read 16th June 1927.)

The investigations of the algal flora of the Baltic and neighbouring waters have clearly shown how important is the influence of salinity as a factor determining the distribution, both vertical and horizontal, of algae which inhabit waters where the value of this factor fluctuates. On the open coasts of the British Isles the fluctuation in the value of this factor is not sufficient for its effect on the broad distribution of seaweeds to be at all marked.

In the case of a tidal estuary, however, the semidiurnal variation of salinity will be very considerable and dependent at any point on the proportions of sea and river water which are mixed, and further, the range of variation is much greater in that the density of sea water tends to prevent its mixing with the fresh water, so that a stratification obtains.

In the present paper an attempt is made to set forth the conditions of distribution of the larger brown algae as found in Aberdeenshire, and to indicate very broadly the relation between this distribution and the salinity.

By the term salinity is to be understood the concentration of the balanced solution of ordinary sea water. Values of salinity were obtained by testing samples of water in the field with salinometers graduated 1.000 to 1.020, and 1.020 to 1.040.

Bottom samples were obtained by means of a tin with a lead weight and a hole at one end. This is let down on a line attached to a bolt which passes through the hole, and has a large soft-rubber washer inside, so that while the tension due to the weight is on the line no water can pass in. On reaching the bottom the bolt drops, and bubbles rise to the surface as the water enters.

A sample from a given distance from the bottom is obtained by attaching the sinking weight by a line of that length.

Minor modifications may be required under certain local conditions, such as rapid currents. It is essential that the washer be free from grit; it may require a little vaseline, and

it is very important to have a weight which is not only sufficient to sink the tin, but also to hold the tin against the washer with sufficient force to counteract the excess pressure outside the tin over that inside, and this excess increases with the depth.

No attempt is here made to use figures for an accurate expression of the salinities, but the few selections of data from the field note-book, where given, are intended merely to illustrate very broadly the conditions of salinity. No complete investigation of salinity conditions could be undertaken in such places without the use of self-recording instruments, since the values depend upon extremely variable factors, such as the amount of water being discharged by the river, the height of the tide, and the general atmospheric conditions which govern these; and for the same reason it would be difficult to obtain minimum, maximum, or mean values for salinities at different localities which could be compared with any degree of nicety.

The approximate salinity values are expressed as the excess in thousandths over a density of 1.000, and the percentage concentration may be obtained approximately by multiplying this figure by 0.13 thus:

Density 1.014 expressed as 14.

Concentration— $14 \times 0.13 = 1.8$ per cent.

It has also been found convenient to express time as the period of ebb or flow based on the nearest high water, thus:

$6^h = \text{h.w.}$; $-3^h.0 = \text{half ebb}$; $0 = \text{l.w.}$; $+3^h.0 = \text{half flood}$.

The estuaries, which, as will be seen, are of different types, will be considered separately. For position of estuaries see fig. 1.

THE DEE, ABERDEEN.

THE HARBOUR AREA. (See fig. 2.)

At one time the estuary of the Dee was more like that of the South Esk at Montrose, with a large area of mud and salt marsh corresponding to the Montrose Basin. But extensive work begun some 100 years ago converted this into the present harbour, which now takes the form of two docks and a fishing harbour leading into a tidal basin, which is a lateral appendage of the estuary on the north side. From the entrance to this

tidal basin the North Pier extends eastwards into the bay. In the west direction the north shore of the river is, in this area, an artificial quay. On the south side, in this area, the shore is rocky, and at the mouth of the river curves south-east towards Girdleness. The South Pier, projecting in a north-east direction, may be regarded as the limit of the area under

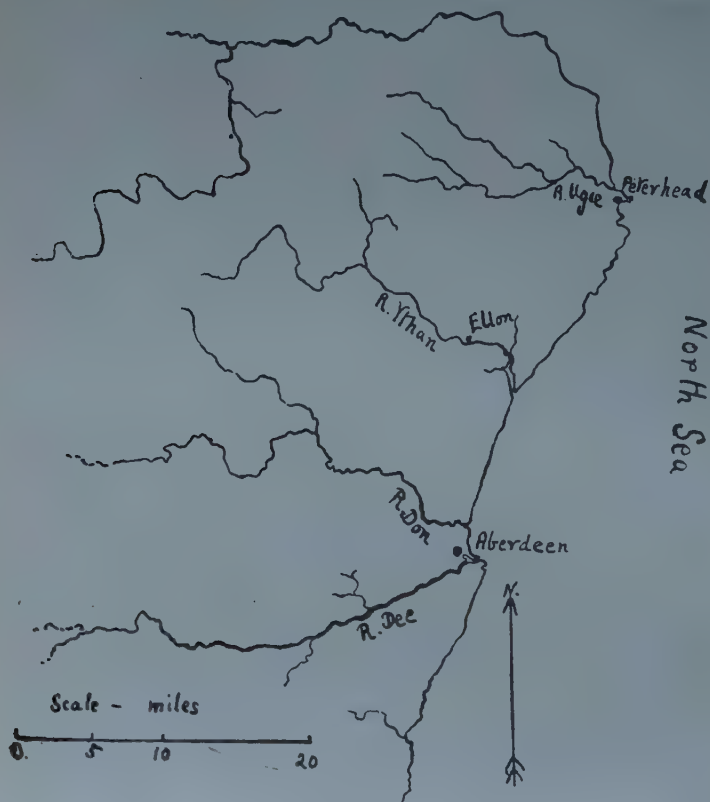


FIG. 1.—Map of the district to show position of the four estuaries.

consideration. This south shore is divided into sections by the South Pier, Old South Pier, South Jetty, and Torry Quay, and for convenience of description these sections are termed the East Bay, West Bay, and Torry Bay respectively. In the centre the channel is about 20 feet deep from mean sea-level.

High-water springs at Aberdeen occur at about 2^h.30, and the mean range for a spring tide is 12 feet and for neaps about

6 feet; but in such an area as this the heights of the tide are necessarily very irregular, and this irregularity is more marked at low water. The above figure for neap-tide range is lower than that published in almanacs, but is derived from daily record of the tides kept at the harbour, reference to which was kindly allowed by the dockmaster.

Distribution.—The distribution of the algae considered is shown in fig. 2. In the East Bay four species occur, *Pelvetia canaliculata*, *Ascophyllum nodosum*, *Fucus platycarpus*, and *Fucus vesiculosus*. All these are abundant in the east half of the bay except on the South Pier itself, where *Pelvetia* and *Ascophyllum* are confined to the basal end. The zonation is well marked, and the vertical ranges of the species are shown in fig. 3, which has been compiled from observations of the tide gauge on calm days. It will be seen that this illustrates a normal zonation. A curious feature in the East Bay is a strip of rock, some 60 feet wide, representing about 4 feet vertically, below the *F. vesiculosus*, where none of these species occurs, the surface of the rocks being covered with mussels and barnacles in the east part, and *Gigartina* in the west part, of the bay. On approaching the Old South Pier, *Pelvetia* and *Ascophyllum* become occasional, and only one or two small plants of each occur on the east side of this pier, marking for both species their upstream limit. The barren area on the chart at this end of the East Bay, and also that at the west end of the West Bay, is due to the substrate of pebbles, which is unsuitable for attachment. On the east side of the Old South Pier, *F. platycarpus* has its upper limit 9 inches to 12 inches above the normal (not indicated in fig. 3), but the reason for this seems clear in that even on a calm day the rising tide is almost always accompanied by a considerable swell which, meeting the pier obliquely, runs up the somewhat sloping side to a greater height than that which it reaches by splashing on the rocks. Some dozen observations made under various conditions when the tide was at this level have shown that the upper limit here is washed by the sea as soon as is the upper limit on the west or protected side, which is 12 inches lower.

The West Bay is occupied by the two *Fuci*. These maintain their normal zoning in general, but the two tend to overlap to a greater extent than when *Ascophyllum* separates the

greater part of *F. vesiculosus* from *F. platycarpus*. There is thus an encroachment by both species into the *Ascophyllum*



FIG. 2.—Chart showing distribution of seaweeds near the mouth of the river Dee, Aberdeen.

zone, and *F. vesiculosus* extends, in the eastern half of the bay, as a dense growth right down to the low-water mark of the larger spring tides, thus occupying the *F. serratus* zone, in contrast to the condition in the East Bay. Near the lower

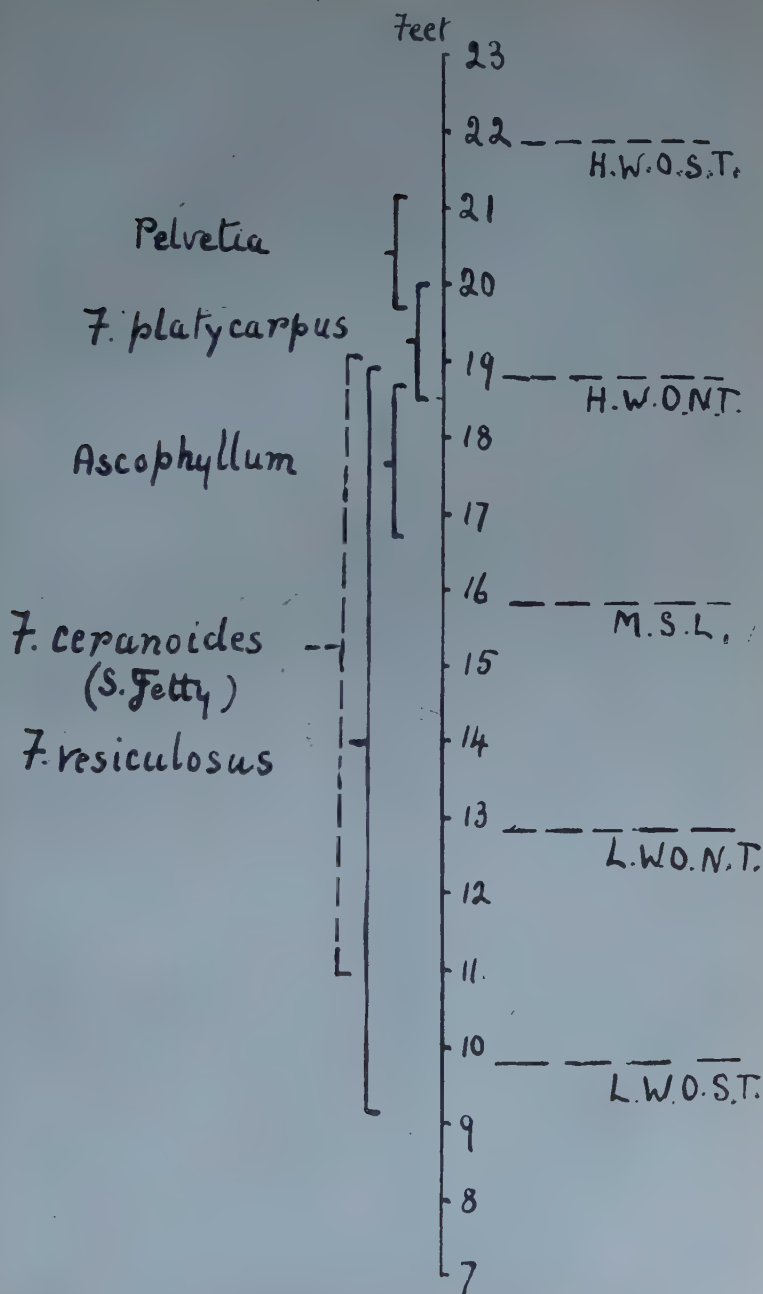


FIG. 3.—Diagram showing vertical ranges of five species in the estuary of the river Dee, Aberdeen.

limit there is a marked increase in the width of the thallus. Towards the west end of the bay it does not extend below the low-water mark of neap tides, and both species are here less frequent and smaller though not otherwise impoverished. The east side of the South Jetty is the upstream limit for both species, except for two plants of *F. vesiculosus*, which have been seen about 15 feet beyond the jetty. There is a noticeable absence of conceptacles in both species towards this limit, and also of bladders in *F. vesiculosus*.

The farther side of the South Jetty is covered with *F. ceranoides*. This also extends upstream where the substrate permits, in a zone which, for the South Jetty and near by, is given in fig. 3. This sharp separation of species by the jetty prevents one seeing in what way they would segregate into vertical zones were they present in the same horizontal zone. In Torry Bay the substrate of large boulders enables *F. ceranoides* to grow in abundance.

The north side of the river has less of interest to show. Sewage from an outlet in front of the Customs House at the base of the North Pier is carried by the current along the side of the pier and is responsible for the paucity of the flora on this side of the pier. None of these brown algae occurs for a considerable distance beyond the outlet, and then only very poorly grown and stunted plants. One or two plants of *F. ceranoides* have been seen a third of the way along, otherwise only *F. platycarpus* and *F. vesiculosus* between the levels 14 and 18 of the tide gauge.

The west side of the Abercrombie Jetty, which is itself immediately to the west of the outlet, is, however, densely covered with *F. ceranoides*, as is also the New Quay, where an occasional *F. vesiculosus* has been seen amongst it. In the harbour itself *F. ceranoides* alone occurs in the few areas where there is a suitable substrate and sufficient freedom from the activities of commerce.

It is of interest that in the immediate vicinity of the area under consideration other large browns occur. Thus *F. serratus* is abundant on the rocks against the north side of the North Pier between levels 11 and 14, and on the distal portion of the same side a clearly defined zone of *Alaria* and *Laminaria digitata* occurs at about 10 feet 6 inches level. On the rocks between the South Pier and Girdleness the

following occur: *Laminaria digitata*, *L. saccharina*, *Alaria*, *Halidrys*.

All these, however, may be considered as free from estuarial conditions.

Salinities.—A brief account of the salinity variation along the south shore may throw some light upon the interesting distribution outlined above. Except at high water, it is the marginal salinity which influences these littoral algae. This has never been found to be zero in this area, and naturally, in general, decreases in value in the upstream direction; but the action of the jetty and piers standing out into the channel modifies this to some extent, especially during a flowing tide. At this time it is found that for each bay the salinity is highest at its west end—at first sight an unexpected condition—though the values for the East Bay are always higher than those for the West Bay. This is found to be due to the upper outgoing fresh current being in part deflected by the piers and so collecting at the seaward end of each bay, which area is at the same time protected by the pier from the incoming tidal current. The reverse process is at the same time taking place on the seaward side of the pier, where the salt current, coming up below, is partly trapped in the west end of the bays. This action has been directly observed for the upper layers by means of floating objects, and has been clearly indicated for bottom layers by bottom salinities, the samples being taken from the piers. With the ebb-tide this condition becomes less marked; both top and bottom layers are running out and hence are acted upon equally.

At any time during a flowing tide and for the greater part of the ebb, marginal values range from 0·5 to 5·0 on the west side of South Jetty as compared with a range of 4 to 12 on the east side. Similarly for the Old South Pier a range of 6 to 10 on the west side and 12 to 19 on the east side.

This sudden change is no doubt the reason why the five species above mentioned all find their limits on the piers.

It must be remembered, however, that, when the tide is up, the greater part of the *F. vesiculosus* and *F. ceranoides* is subjected to higher salinities than the marginal readings indicate. These may approach that of ordinary sea water as far up as the South Jetty. Thus on a typical occasion at a

mean high water and a normal outflow of the river the salinities were :

West side of South Jetty, surface—4 ; bottom 7 feet deep in *F. ceranoides* zone—17.

East side of South Jetty, surface—10 ; bottom 7 feet deep in *F. vesiculosus* zone—22.

And for places nearer the sea almost full sea salinity is reached at high water in the areas occupied by *F. vesiculosus*. What would, in this respect, appear to be an important point is the fact that these algae are washed by comparatively fresh upper layers before their period of exposure to the atmosphere.

BRIDGES AREA. (See fig. 4.)

The river becomes shallower as we pass inland until the bend between the Victoria and Wellington Bridges, where it is about 8 feet deep at a mean high water. From there it becomes deeper, attaining a maximum depth of about 20 feet just south of the Wellington Bridge, and becomes very shallow beyond the Railway Bridge.

Distribution.—*F. ceranoides* alone of these forms grows in this area. Up to the Wellington Bridge its distribution and frequency is determined by the nature of the substrate, in parts sandy and pebbly and elsewhere of artificial stonework. The latter and the piers of the Victoria Bridge bear *F. ceranoides*. The area between the Wellington and Railway Bridges is rocky, especially on the east side where, near the Wellington Bridge, the rocks descend vertically 20 feet into the water. On this side of the river *F. ceranoides* is very abundant, but becomes less frequent near the Railway Bridge, not because of the substrate, which is still rocky, but because it is here approaching its upstream limit, which is also indicated by the poor growth of the plants. It occurs on the piers of the Railway Bridge, though only on the seaward side, and a few plants may be found for a quarter of a mile beyond on the south side.

It is clearly unnecessary for *F. ceranoides* to be subject to exposure to the air, since its lower limit is some 2 feet below the surface at low-water springs with a fairly empty river ; and this observation is corroborated in other rivers. This condition indicates the probability of light being the limiting factor in this area. On approaching its upstream limit the

upper vertical limit becomes lower, so that at its upstream limit none of the plants is usually subject to exposure at low water.

The growth forms at limits will be referred to subsequently.

Salinities.—At low-water neaps the whole of this area contains fresh water, and with the rising tide salt first reaches the Victoria Bridge between +2.30 and +3.30 according to conditions, and the Wellington Bridge some twenty minutes

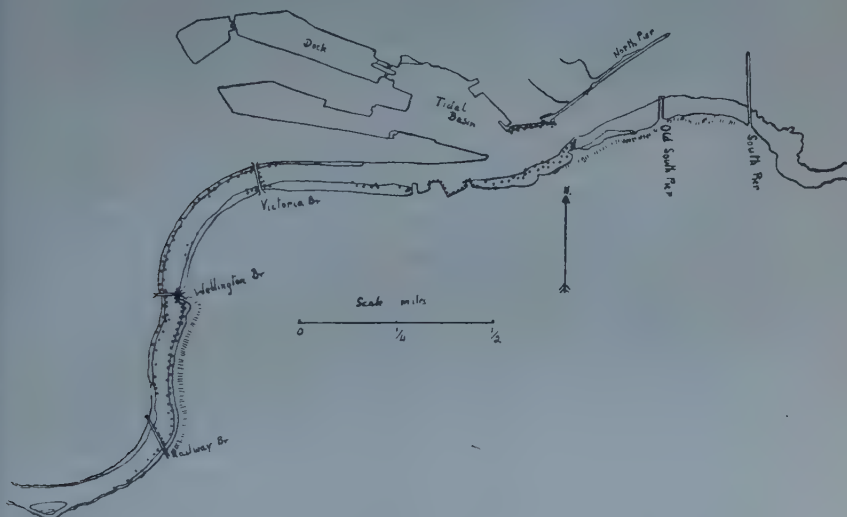


FIG. 4.—Chart showing distribution of *Fucus ceranoides* in the river Dee, Aberdeen.

later, and is found at the bottom at high-water neaps, almost as far up as the Railway Bridge, with a salinity of 15 to 20, and at Wellington Bridge and seawards thereof with a salinity of 20 to 24. These values decrease towards the surface, and the following figures, selected for their approximation to average conditions, show the conditions at the Wellington Bridge on 14th February 1927 at +4, when the surface of the water was level with the top of the *F. ceranoides* zone.

Depth in feet .	0-3	5	10	18 (bottom).
Salinity	0	4	20	24.

This salt water runs out during the first half of the ebb, the bottom layers being the last to show decreasing density.

At spring tides the salt comes up rather earlier, e.g. at the Victoria Bridge an increasing salinity may be found at the

bottom at $+2^h$. A salinity of 23 may occur at the bottom as far up as a quarter mile beyond the Railway Bridge at high-water springs, when the water will be only 10 feet deep, and yet a surface sample will be quite fresh.

At spring tides, and when the river is not in spate, the salt water is retained in the deeper parts near the Wellington Bridge throughout the tidal cycle, so that at low water the salinity at the bottom by the Wellington Bridge, 13 feet deep, may be 19, while that at the Victoria Bridge, where the bottom will be $5\frac{1}{2}$ feet deep, may be 1 to 5, indicating that some of the retained salt is being washed down the river.

THE DON, ABERDEEN (fig. 5).

This is a smaller river than the Dee, and the estuary differs in that its bed is at a higher level, so much so that all the salt water runs off into the sea at low water. The mouth is very narrow and bottle-necked, with a relatively wide tidal area behind extending up to the Old Bridge of Balgownie, where the river becomes narrower. Across the middle of this area is the new Bridge of Don, only the piers of which are indicated in fig. 5. An island lies between the two bridges and is connected to the north bank by a ford. A small millstream flows in on the north side of the island. Under the old bridge, where the bed and sides are entirely of rock, the water is some 20 feet deep. It then becomes shallower towards the island, and the main channel, as seen at low tide, is constricted by ledges of rocks to a narrow and, at low water or ebb, a rapid course to the south of the island. Before passing under the new bridge it widens out, and the whole bed of the river is shallow and stony. In passing under the new bridge the channel also crosses over to the north side, leaving, on the south side, a large area of mud and stones. Immediately behind the mouth is a shallow sandy bay on the north side and a muddy bay on the south side; the latter formerly extended southwards into a tract of marsh, now reclaimed and forming part of the links. The mouth takes the form of a narrow channel cut through the dunes. Formerly its position was unstable, with a tendency to wander southwards, but this condition has now been rectified by the construction of a causeway of boulders and stakes on the south side of the channel.

Of the larger brown seaweeds only *F. ceranoides* is present in the Don, and that in abundance. The centre of its dis-

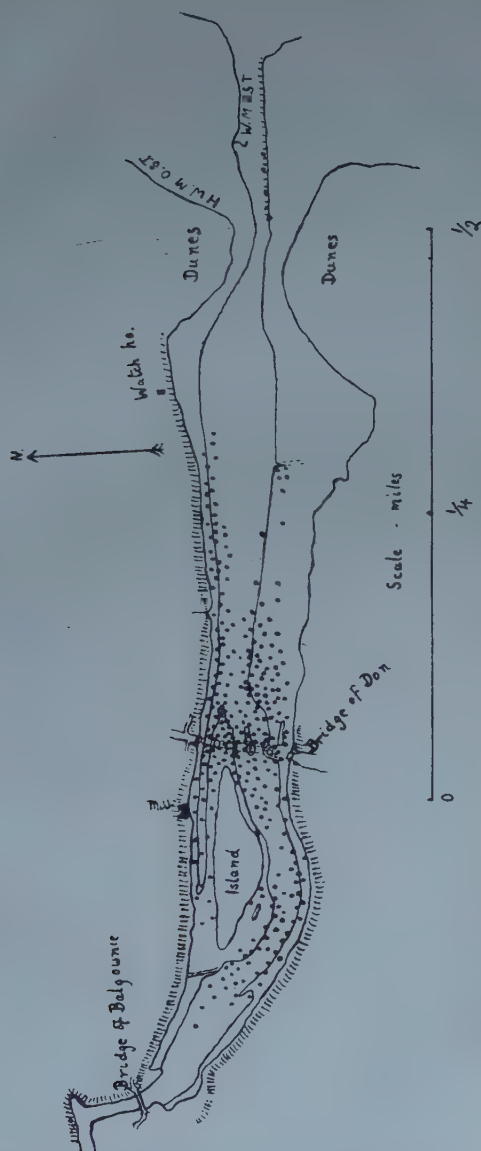


FIG. 5.—Chart of the estuary of the river Don, Aberdeen, showing distribution of *Fucus ceranoides*.

tribution is round the new bridge. The fact that a few plants occur on the near end of the causeway indicates that its

absence from the wide area immediately behind the mouth is attributable to the unfavourable substrate of mud and sand rather than to salinity conditions.

Its upstream limit is between the island and the old bridge. With regard to its vertical range, the general upper limit is such as to be reached by the tide at +3.15 on an average, and to be exposed again at about -2.45, but a few plants may be found in places 9 inches above this level. Thus the upper limit occurs at 6 or 9 inches above the mean tide level, and does not extend, even in extreme cases, as high as it does in the Dee.

The fact that the lower limit in the Dee is too low to be referable to periodical exposure suggests that light is the determining factor. This suggestion finds support here; beneath the new bridge the river is very shallow at low water, and the *Fucus* grows abundantly right across the bed of the river, but where it is deepest, owing to the main channel, it can be seen by a glance from the bridge, when the water is clear and quiet, that the *Fucus* is less abundant in this deeper part, which may be 12 to 18 inches deep.

The condition of the river at high water is determined chiefly by the tide and the factors affecting the tide, while at low water the condition depends upon the outflow of the river and the factors affecting this, such as rain and frost.

A large outflow gives rise to more rapid filling of the estuary during flood, but a later appearance of salt water at the bottom. At the new bridge salt appears in the deepest parts at about +3 normally, and is all gone again by -3. The greater part of the *Fucus*, which is more than 2 feet above this level, is subject to fresh water for some eight hours or more each tide. The highest salinity recorded under the new bridge is 23, but with a small tide it may reach only 15.

The surface layers very rarely show any salt content, and then only 0.3 to 1 at high water, and that normally when a strong wind has disturbed the water. A series of samples from different depths at high water shows that the salinity changes fairly sharply at a definite level. Thus, on one occasion of a mean high water :

Depth	0-2 feet.	3 feet.	4 feet.	5 feet.	7 feet.	8 feet.
Salinity	0	1	3	14	16	18

For this reason a series of samples from the bottom over a period including half flood or half ebb shows an apparently sudden inflow or exit of salt water.

Not at every tide does the salt water reach the old bridge, and with a large tide the outflow of the river will determine whether or no it reaches this point. At any tides larger than a 24-foot tide (which represents the smallest spring, or almost a mean tide), salt may reach the old bridge, but is detectable only at the bottom.

THE UGIE, PETERHEAD (fig. 6).

This estuary is comparable with that of the Don rather than the Dee. The outlet is over a slight fall east of a footbridge,

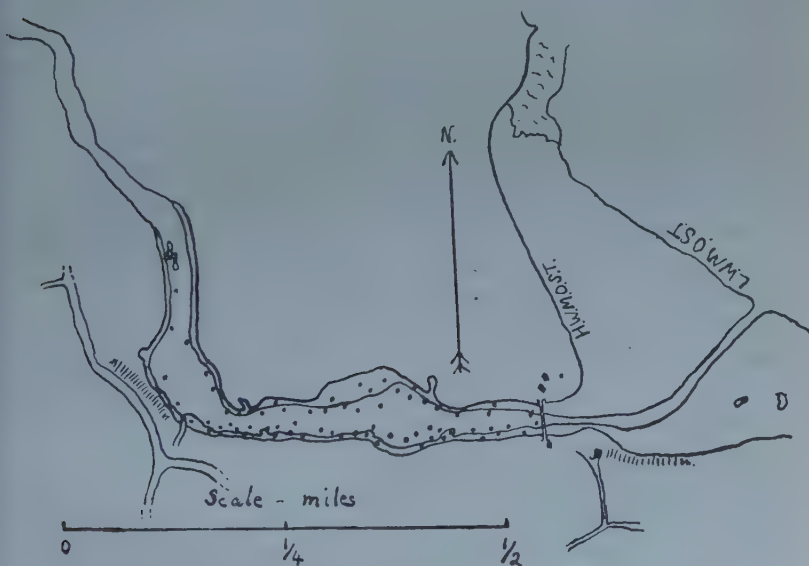


FIG. 6.—Chart showing distribution of *Fucus ceranoides* in the river Ugie, Peterhead.

to the top of which the tide reaches at about ± 3 , and from then begins to fill up the tidal tracts of the estuary. *F. ceranoides* is abundant. Towards its upstream limit it is not exposed so much at low water. Along the south bank, where it is at its best, it is often found in the lower zone of phanerogams with *Cochlearia*, grasses, etc. This is notably in contrast to the

conditions in the Don ; opportunity was not found for determining the tidal level of the upper limit for comparison with that in the Don. The bridge-keeper states that the tide runs in rapidly and that the water is noticeably salt at high water. There is no true halophytic vegetation, however, in the tidal zone on the banks.

THE YTHAN, NEWBURGH (fig. 7).

This presents a different type of estuary. Having a very slight gradient it is tidal for 6 miles, and, since the estuary is very wide for the first $3\frac{1}{2}$ miles, an enormous amount of water rushes in and out during a tide, and this in spite of a remarkably narrow mouth through the dunes. Here is no case of fresh water flowing out on the top of the incoming tidal water, but at the bridge $1\frac{1}{2}$ miles from the sea the water at half flood is rushing up at 3 to 5 miles per hour. It is in fact the local practice to barge up to Ellon on the flowing tide.

The greater part of the estuary is muddy and unsuitable for seaweeds, but where they do occur it is seen that the effect of this type of estuary is to enable the horizontal zones of those species which were so sharply separated in the Dee to overlap one another. Thus at point A on fig. 7, where the substrate is rocky for a little distance, *Pelvetia*, *F. platycarpus*, *Ascophyllum*, and *F. ceranoides* are found in this order of vertical zones. This point is almost the upstream limit for *Ascophyllum*, and *Pelvetia* disappears shortly after. *F. platycarpus* goes next farthest up, and then only *F. ceranoides* is to be found almost as far as Logie Buchan, that is 2 miles from its seaward limit between the bridge and point A. *F. vesiculosus* has not been found farther up than *Pelvetia*, and does not appear to be present at point A.

Something may here be said of the effect of unfavourable conditions on the growth form of *F. ceranoides*. This may be well studied in the Don. Where slackness of water allows much sedimentation of mud, as on the north side of the island in the Don and elsewhere, the *Fucus* is of a very poor form, small, narrow, and sterile. The best plants, which may be 3 or 4 feet long, and portions of which are illustrated in Nos. 5 and 6, Pl. XIII, are, apparently for this reason, to be found on the bed of the river and near to the main channel.

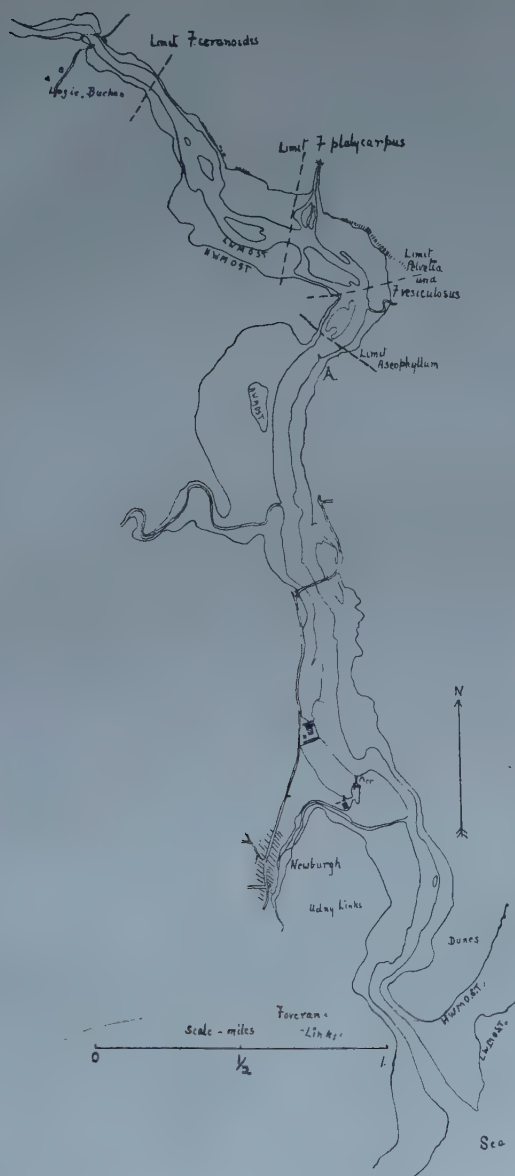


FIG. 7.—Chart showing limits of five species in the river Ythan, Newburgh.

The effect of a high vertical zone is to reduce the plants, though the factor of exposure is often mixed up with that of sedimentation, because the water is always slackest when the tide is up, so that those plants which are only submerged during high water are necessarily subject to more sediment. But, in spite of this, the stunting effect of over-exposure is quite clear. Nos. 2, 4, and 3 in Pl. XIII show respectively plants from near low-water mark, middle zone, and top limit on north bank of Don to east of new bridge. No. 1 shows a characteristic form with many vegetative sprouts from the same zone as No. 4. This form is frequently met with where much silting occurs, and may be a character correlated with the tendency to sterility noticeable in muddy places. Reduction of conceptacles occurs where silting is pronounced, next the upper vertical limit and towards the upstream limit. At the latter place the plants show a generally impoverished form, though of a straggly rather than a shortly stunted form, as occurs at the upper vertical limit. These forms are to be found in other rivers under the same conditions where they exist. Close to the South Jetty in the Dee, which is the seaward limit for *F. ceranoides*, it is interesting to note the forms of the plant at the upper and lower vertical limits. The form of plant characteristic of the lower limit is illustrated in No. 7, Pl. XIV, and, as it is not below the low-water mark of spring tides, it appears to be determined by too high salinity rather than by need of light. The plants at the upper limit are smaller than the normal, though they do not show the irregularities of the thallus seen in the lower forms. At this place there is no appreciable silting of mud. Farther upstream at the lower limit, which is apparently determined by light intensity, there is but little modification of the plant—a fact which suggests that the deficiency of the limiting factor is probably most felt during early stages of the plant's life.

Inflation of the thallus is sometimes seen, but never so commonly or to such an extent as in the *F. ceranoides* of the south coast of England. It is also to be noted that while several hundreds of plants have been examined not one has been found to be hermaphrodite, nor even to show evidence of abortion of sex, as is frequently seen in this species. Stomps (1911) finds a tendency towards hermaphroditism in the upper

zones at Nieuport and to unisexuality in lower zones. He also illustrates transitional series between the three species *F. vesiculosus*, *F. platycarpus*, and *F. ceranoides*, which may be seen towards the *F. ceranoides* zone, where they become almost indistinguishable from one another. He puts forward the suggestion that they may be zonal forms of the same species.

Such apparently transitional forms may be seen at Aberdeen, but, when difficulty has arisen in determining the species, they have been put into the species of their immediate neighbours.

In the top vertical zone of *F. ceranoides*, near its seaward limit in the Dee, *i.e.* in "Torry Bay," there are plants with the thallus and receptacles more characteristic of *F. platycarpus* than of *F. ceranoides*, but since they differ from the true *F. platycarpus* in being unisexual, they have been considered as forms of *F. ceranoides*.

There is very little literature descriptive of similar areas round our coasts. The conditions described by Cotton (1912) for the Newport River are in agreement with those at Aberdeen, except in the order of disappearance in the upstream direction. Here, however, there is a definite overlapping of the *F. ceranoides* with the other species. The same four species are found at the mouth, and *F. ceranoides* first appears in the *F. spiralis* zone, which it monopolises, and in the lower part of *Pelvetia* zone. The *Pelvetia* shortly after disappears and *F. ceranoides* increases, usurping the *F. vesiculosus* and *Ascophyllum* zones. *Ascophyllum* is the last to disappear, leaving only *F. ceranoides* from a quarter of a mile below Newport to its upstream limit. Near Newport Bridge it extends, apparently, right across the river, and towards its upstream limit is subject to fresh water for many hours at a time. The plants of the upper vertical zone are stunted and may be barely 1 inch long.

In a case cited by Kleen for the Norwegian coast (see Kniep, 1907), the order of disappearance towards a basin of low salinity connected to the sea by a narrow channel is *F. serratus*, *F. vesiculosus*, *F. Sherardi*, and *Ascophyllum*; *F. ceranoides* alone growing in the basin. The same order is found in the Baltic waters. Thus in these cases *Ascophyllum* is second only to *F. ceranoides* in upstream extension, though this is not the case at Aberdeen.

Of particular interest in connection with the distribution of

these seaweeds in estuaries is the work of Kniep (1907) on the biology of *Fucus*. He has determined for the species of *Fucus* the minimum, optimum, and maximum values of salinity for the various reproductive processes, *e.g.* discharge of gametes, motility of sperms, fertilisation, and germination of zygote. *F. ceranoides* is, however, not dealt with.

A complete bibliography of works on the factors governing the distribution of algae will be found in Oltmann's "Morphologie und Biologie der Algen," iii (1923), 451.

Those immediately referred to in the above account are given below.

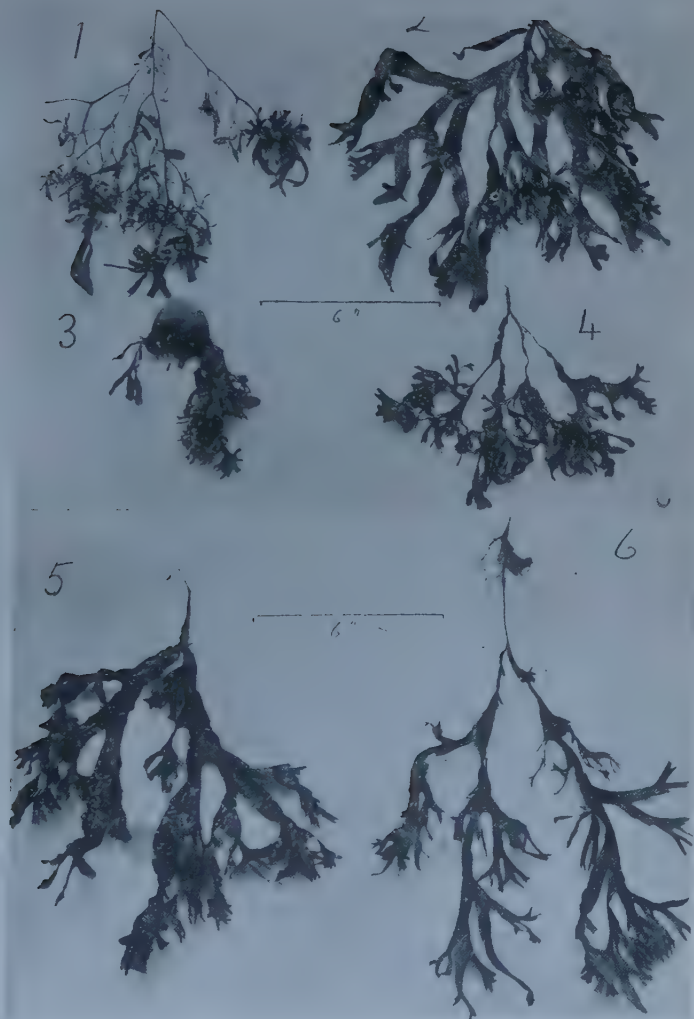
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DESCRIPTION OF PLATES XIII, XIV.

Nos. 1-7 illustrate forms of *Fucus ceranoides*.

1. Plant with vegetative sprouts, from an intermediate zone in the Don.
2. Plant from near low-water mark in the Don.
3. Plant from upper vertical limit in the Don, showing the stunting effect of exposure.
4. Plant from intermediate zone in the Don—between that of No. 2 and that of No. 3.
- 5 and 6. Portions of normal plants from the bed of the main channel in the Don.
7. Plants from the lower limit near the South Jetty in the Dee, above low-water mark of spring tides.





ANATOMY OF THE GENUS MESEMBRYANTHEMUM. I. ROOT
STRUCTURE. By CHRISSY I. KEAN, B.Sc. (With Pls.
XV-XVII.)

(Read 16th June 1927.)

The roots of all the Mesembryanthema show anomalous structure in the stele, and at first sight this appears to be of two different types. Morot (1) in his work on the pericycle refers to these in dealing with *M. stelligera* and *M. foliosum*, indicating how the one type is developed from the other. A further study reveals the fact that there are more than two, and in addition several intermediate types.

The origin of the anomalous cambiums in the roots of this and other allied orders has been disputed. De Bary (2), on the one hand, gives it in the phloem, and Morot (*loc. cit.*) and Van Tieghem (3) in the phelloderm. With these points in view an examination was made of the roots of fifty-seven species.

Type 1.—Only one species, *M. inflexa*, is included in this section. The primary stele is diarch or triarch, the xylem and phloem being separated by one or two layers of parenchyma. One layer of small cells, occasionally duplicated opposite the phloem areas, forms the pericycle. The two innermost layers of the cortex form an endodermis of square cells with thin suberised walls (Plate XV, fig. 1). The outer layer is the more heavily suberised and the cells in the two layers alternate. Several cells of the inner layer contain raphides. The cortex consists of about six layers of large spherical cells with clear contents. The walls, which are of hemicellulose, become progressively thinner centrifugally and bear numerous, narrow, obliquely placed, simple pits. The integument of the primary root is a normal piliferous layer succeeded by an exodermis.

Incidentally several cells of the inner cortex, particularly next the endodermis, are infected by fungal hyphae forming compact wefts, almost a pseudoparenchyma (Plate XV, fig. 2). The hyphae are non-septate and ramify also in the inter-cellular spaces, a few ends passing out to the exterior between two piliferous cells. Certain other cells contain light brown spherical structures completely filling the cells, probably the

ultimate stage of the same fungus. This would indicate an attempt at mycorrhizic formation but is of little significance, as the cortical tissue is cut off at an early stage by cork formation. This is the only species in which the fungus was observed.

A normal cambium originates between the xylem and phloem where it lays down a small amount of secondary tissue. It is extended round the poles of the xylem by the parenchyma after a short time, but it continues to be most active in the region of the primary phloems. Consequently the stele which was oval or three-rayed in section becomes cylindrical.

The normal cambium functions for a short time only, but before it has ceased activity a new cambium is formed from the outermost layer of the phloem. This is in accordance with De Bary's view regarding roots of *Mesembryanthemum*, though he does not state which layer of the phloem is involved. Van Tieghem (*loc. cit.*) and Morot (*loc. cit.*) in dealing with the roots of the *Chenopodiaceae*, *Amarantaceae*, *Nyctaginaceae*, and *Aizoaceae* give the inner layer of the phelloderm as the cambial mother tissue, which in the case of *M. inflera* is impossible, as the anomalous stelar thickening begins slightly before periderm formation.

This cambium lays down internally first parenchyma, then sclerenchyma, and subsequently a few vessels and tracheids, while externally a few layers of phloem are cut off. The vessels and tracheids and also the phloem elements thus laid down constitute a system of radial collateral strands separated by rays, sclerenchymatous in character between the xylems and parenchymatous between the phloems. A section now shows, when the stele is diarch, a central xylem cylinder surrounded by soft tissue with externally two lignified areas, or when the stele is triarch three lignified areas (Plate XV, fig. 2). Through cambial activity these become joined up to form a ring which becomes disrupted from time to time by the outgoing lateral roots.

This second cambium after a time ceases activity and is replaced by a third, which may be succeeded by a fourth and even a fifth. Each new cambium arises in the outer layer of the phloem formed from the previous cambium, and gives rise to the sequence of tissues already described. The two or

three rows of lateral roots are so close that the rings are rarely complete in any section.

Medullation occurs in triarch roots of this and eight of the other species examined, and Morot records a large pith with five-arch xylem in *M. foliosum*. Originally the stele is solid with a little xylem parenchyma between the primary and secondary xylem. The first evidence of pith formation is the breaking away of one arch from the others by proliferation of the parenchyma cells in the xylem, and intrusion of the parenchyma where a rootlet is given off. A little later the two other arches separate in the same way and a substantial pith is formed (Plate XV, fig. 2).

Almost simultaneously with, but slightly later than, the formation of the secondary cambium, the pericycle gives rise to a cork cambium which remains active during the life of the root, giving rise on the inner side to a few layers of phelloderm and externally to a large amount of cork. The cork gradually becomes ruptured, and the phelloderm is stretched tangentially as the root increases in thickness. The clefts are few in number and may go as deep as two-thirds of the whole cork layer. Very often there are four of these, one at either side at the points at which the rootlets have passed out, but this is not constant (Plate XV, fig. 3).

Calcium oxalate occurs in large amount as raphides in all the parenchymatous areas—pith, parenchyma developed from the stelar cambiums, and the phelloderm. In the primary root they occur also in the inner layer of the suberised endodermis, and in the old root in large amount in the cork.

Droplets of oil and protein grains are also observed in all the parenchymatous tissues.

Type 2.—*M. lepidum* may be taken as typical of this section, which includes the majority of the species examined. The primary structure and normal secondary thickening are identical with that of *M. inflexa*, except that cork formation begins before the anomalous cambium is developed.

Anomalous thickening begins as before by an arc of cambium arising in the external layer of the phloem at two points at right angles to the protoxylems. Meanwhile the primary cambium has laid down a certain amount of xylem opposite the protoxylems and has come into line and coupled up with the new secondary cambium so forming a complete ring, and

the xylem, primary, secondary, and tertiary forms an 8-shaped structure. The tissues laid down by the anomalous cambium are parenchyma, sclerenchyma, vessels, and tracheids in radial strands separated by conjunctive sclerenchyma, and phloem elements also in radial strands separated by rays of parenchyma. The 8-shaped structure is broken by outgoing branch roots which arise opposite the protoxylems and pass out accompanied by branches from the secondary arches (Plate XV, fig. 4). Sometimes the primary xylem bar of the rootlet is in a plane not at right angles to the xylem bar of the old root, and hence the branch from one arch passes out earlier than the other. If a root comes off obliquely at both poles in this way, and if the obliquity is in opposite directions, an S-shaped structure is produced (Plate XV, fig. 5), but if the obliquity is in the same direction a structure as in fig. 6 (Plate XV) is obtained.

When the second cambium ceases to function, two new arcs of cambium arise at right angles to the previous in the outer layer of the last formed phloem. This cambium is extended through the parenchyma and forms a complete ring as in *M. inflexa*, and the rings subsequently formed are identical in structure and arise as already described.

At intervals small areas of the parenchyma between the rings become lignified and form bridges linking up the various zones of lignified tissue. Usually two of these bridges occur between each two rings, and as many as five or six rings of anomalous thickening may be found in an old root.

The disruption and joining up of the xylem becomes still more complicated when several rings are involved. Starting with an E-shaped structure as in Plate XV, fig. 4, instead of joining up with the central cylinder, the two arches may join up together (Plate XVI, fig. 7). If a root is now given off obliquely at the opposite pole, a spiral is formed (Plate XVI, fig. 8). As the second arch gives off a branch the spiral disappears and the arches may join on to the central cylinder giving the normal structure (Plate XVI, fig. 9), or they may join up together forming a complete ring, and any number of roots may be given off before the arches again join on to the central cylinder. In a still older root a spiral may be formed starting from the primary xylem bar. The first stages are similar to those already described. The branch root is oblique and one

arch joins on to the central cylinder. Meanwhile the cambium has laid down a little xylem, *i.e.* it has been pushed slightly outward, and here it must be assumed that there is overlapping in the activity of the successive cambiums, although this is not evident in every case. In addition there is slight radial stretching on the free side. These two factors combined cause the cambium of the inner ring to be brought into line with the more recent cambium, and so alternate rings are joined up and a spiral is formed (Plate XVI, fig. 10). If the roots come off as in Plate XV, fig. 5, a double spiral occurs as in Plate XVI, fig. 11. From these observations it is evident that when a root comes off obliquely a spiral is formed, and when horizontally a series of concentric rings.

Raphides, oil droplets, and protein grains occur in the same tissues as in *M. inflexa*.

Adventitious rootlets arise at any point on the root and proceed from the outer xylem ring, or from the two outer rings. They have their origin in the anomalous cambium and pass out, in the latter case from the second layer, with a branch on either side from the outer layer.

In several species, *e.g.* *M. tenellum*, all the tissues laid down internally by the anomalous cambiums become lignified so that the only cellulosic tissue in the stele is the phloem and an occasional patch of parenchymatous tissue between two or more phloem areas (Plate XVI, fig. 12).

M. roseum, although of the same type as *M. lepidum*, shows one or two interesting features. The first anomalous cambium remains active in the radius of the primary phloems, and the second pair of arches join on to the first. This phase is very brief, however, and does not recur after a branch root has been given off. The ends of the arches join up and a ring is formed.

The rootlets do not pass out in a straight line as they do in *M. lepidum*, but curve alternately in opposite directions before passing out, and so apparently there are four rows of branch roots given off (Plate XVII, fig. 13). Bridges between the rings are seldom seen.

The occurrence of adventitious rootlets is more marked in this than in any of the other species. They occur especially in the radius of the primary phloems where they are given off from either of the rings, including the first (Plate XVII, fig. 14).

Type 3.—In this section, of which *M. pugioniforme* is the

type, the anomalous cambium which arises as in the previous species lays down internal parenchyma of which only little groups of cells become lignified. At first there are about three of these groups, but later six and still later eleven, and it is in these areas that the vascular tissue is laid down and eleven collateral bundles are produced. A third cambium arises as before, and a second ring of bundles is laid down. Morot (*loc. cit.*) gives a similar structure in his description of *M. stelligera*, but states that the cambium does not form rings but merely arcs in the bundles, and that the conjunctive parenchyma becomes stretched to accommodate the new tissues. In *M. pugioniforme* it is quite obvious that new parenchyma cells are formed between the bundles indicating a cambium ring. After development of the stele has taken place to this extent, the root becomes temporarily thick and succulent. This is brought about by increase in size of the parenchyma cells, and not by formation of new cells. They are highly turgescient, with small intercellular spaces, and are crammed with starch grains. A few crystallogenous cells occur containing raphides. The cambiums are still active and the bundles increasing in size both radially and tangentially. After a time shrinkage occurs; the parenchyma cells recover their normal size, thus reducing the diameter of the root and drawing the bundles closer together, so that the rings of xylem appear to be almost complete. When the root becomes tuberous the axile strand of the stele is disrupted opposite the protoxylems, giving a four-rayed appearance. A small amount of xylem parenchyma occurs in these areas, and this shares in the turgescence along with the other parenchyma of the root, but these cells undergo division, and so when contraction occurs the wedges of parenchyma become narrower, but the rayed appearance still persists (Plate XVII, fig. 15).

There are two species which are intermediate between Types 2 and 3. The first stages of *M. bulbosum* are of the *lepidum* type with an 8-shaped structure, but in the rings subsequently produced the conjunctive tissue is of parenchyma like that of *M. pugioniforme* (Plate XVII, fig. 16). Marked succulence occurs in this species also, but it is due to growth, and it extends to the base of the root. The parenchyma cells increase in size and the walls become thickened and bear simple pits.

M. crassulinum also produces an 8-shaped structure, but

wide rays of parenchyma occur giving an appearance rather like the first stages of *M. pugioniforme*. In the later formed rings the conjunctive tissue is of sclerenchyma, which is characteristic of the *M. lepidum* type (Plate XVII, fig. 17).

Type 4.—*M. cultratum* and several other species are included in this type. The primary stele may be two, three, four, or five arch. An 8-shaped structure is produced in diarch roots and a corresponding structure in the other forms, but after the stele has become ruptured to allow the rootlets to pass out, this formation disappears and a series of concentric rings is formed. Rays of parenchyma occur in the rings, and in this the root approximates in structure to *M. pugioniforme*.

Medullation occurs in some, but not all, roots, and never in diarch roots. In the primary stele there are one or two layers of parenchyma between the xylem and phloem, and when secondary thickening occurs these are represented by a few cells between the metaxylem and the secondary xylem. In old age these cells become active and divide, pushing apart the vessels of the primary xylem, assisted by intrusion of parenchyma. Hence a pith is formed, sometimes of parenchyma, sometimes with a few scattered vessels in the parenchyma.

It may be observed that although these four types are quite distinct, they are linked up together by various characters, and their relationship is quite definite. In every case the species has some feature common to one or more of the other types.

In conclusion, the writer has to express her indebtedness to Professor Wright Smith and to the Gardens of La Mortola for seeds, and to Mr. R. A. Robertson of St. Andrews University for facilities and assistance in carrying out this investigation.

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- (2) DE BARY: Comp. Anat. of Phanerogams and Ferns, Eng. trans. (1884), p. 590.
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DESCRIPTION OF PLATES.

PLATE XV.

Fig. 1. Transverse section of the primary root of *M. inflexa*, showing the diarch stele and double endodermis.

Fig. 2. Transverse section of an older root of *M. inflexa*, showing a medullated triarch stele with the first anomalous arches and the beginning of periderm formation. The inner cortical cells are infected by fungus hyphae.

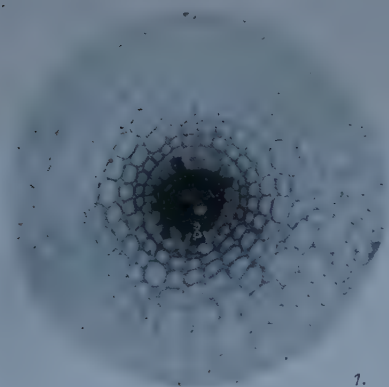
- Fig. 3. Transverse section of a root of *M. inflexa*, with cork formation. There are three clefts in the cork layer.
- Fig. 4. Transverse section of a root of *M. lepidum*, showing the rupture of the stele at the outward passage of a rootlet giving an E-shaped structure.
- Fig. 5. S-shaped structure in a transverse section of a root of *M. lepidum*, caused by rootlets coming off obliquely at both poles, the obliquity being in opposite directions.
- Fig. 6. Same as fig. 5, but the obliquity is in the same direction.

PLATE XVI.

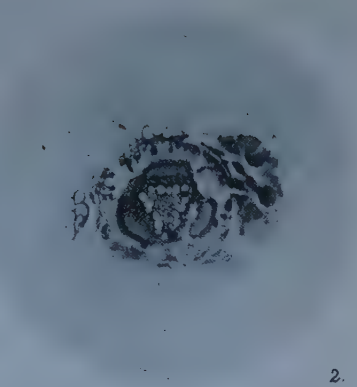
- Fig. 7. Transverse section of an older root of *M. lepidum*. The arches have joined up together after a rootlet has passed out. The section also shows a second but incomplete anomalous ring.
- Fig. 8. Transverse section of a root of *M. lepidum*. The arches have joined up on the right, and on the left a rootlet has been given off obliquely, giving a spiral.
- Fig. 9. Transverse section of a still older root of *M. lepidum*, showing an 8-shaped central mass and two other anomalous rings.
- Fig. 10. Transverse section of an old root of *M. lepidum*, showing a spiral involving two rings where there is cambial activity in both.
- Fig. 11. Transverse section of a root of *M. lepidum*, showing the double spiral brought about by the rootlets at both poles coming off obliquely.
- Fig. 12. Transverse section of a root of *M. tenellum*, showing complete lignification in the later formed anomalous rings.

PLATE XVII.

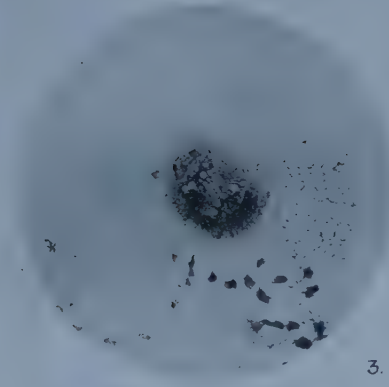
- Fig. 13. Transverse section of a root of *M. roseum*, showing curvature of the rootlet as it passes out.
- Fig. 14. Transverse section of a root of *M. roseum*, showing an adventitious rootlet passing out in the radius of the primary phloem.
- Fig. 15. Transverse section of an old root of *M. pugioniforme*, showing the four-rayed appearance of the central cylinder caused by the disruption of the stele when the rootlets are given off, and by proliferation of the parenchyma cells.
- Fig. 16. Transverse section of an old root of *M. bulbosum*, showing an 8-shaped structure at the same stage as in fig. 6 of *M. lepidum*, and a ring of collateral bundles.
- Fig. 17. Transverse section of a root of *M. crassulinum*. The original 8-shaped structure is lost by the formation of wide rays of parenchyma. The next ring has conjunctive sclerenchyma.
- Fig. 18. Transverse section of a root of *M. cultratum* to show medullation. The stele is four arch, and the pith shows discrete tracheids.



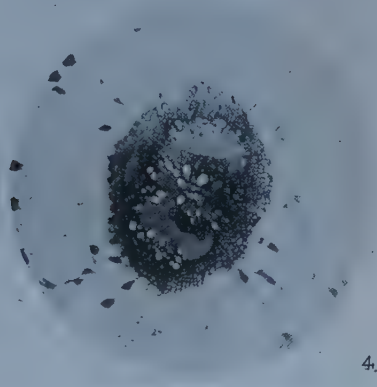
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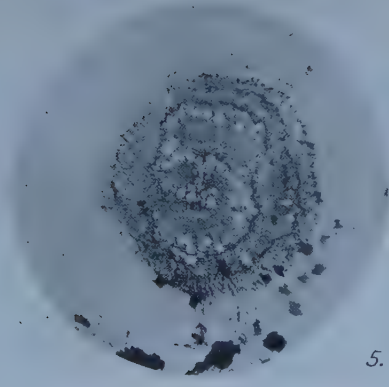
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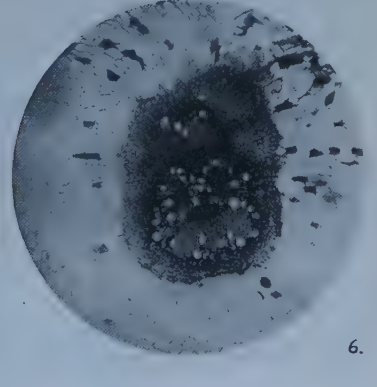
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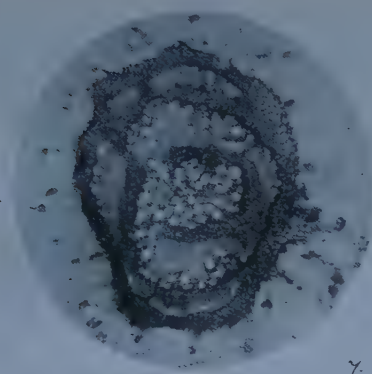
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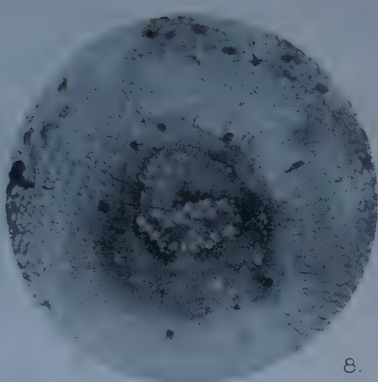
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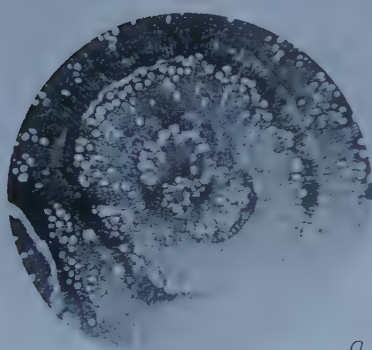
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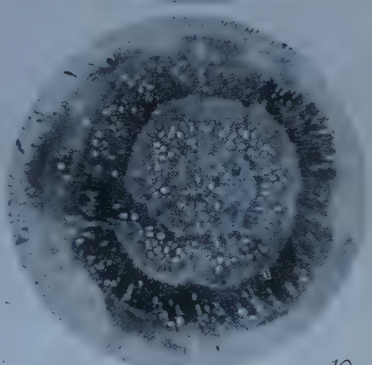
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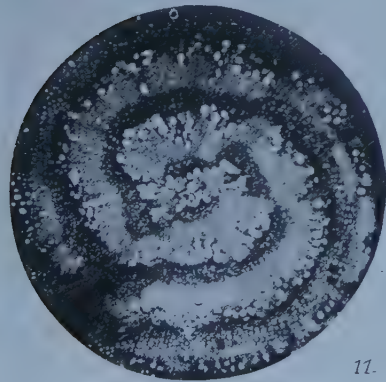
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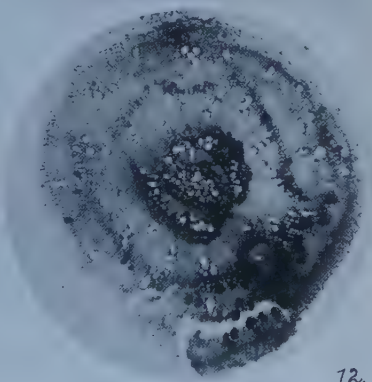
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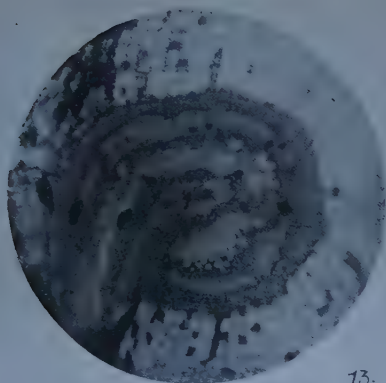
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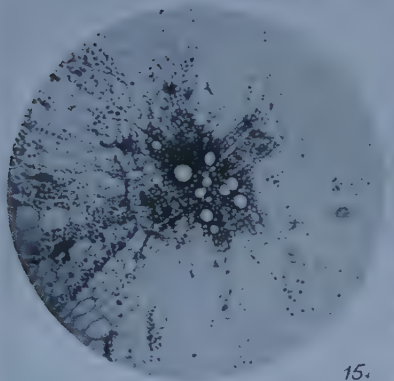
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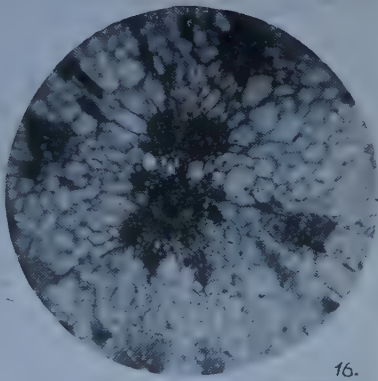
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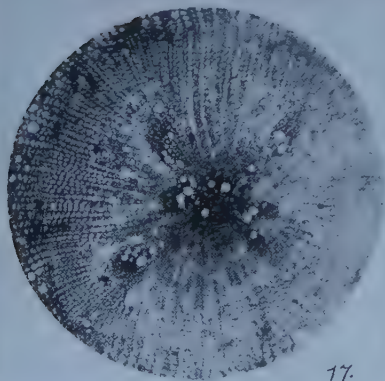
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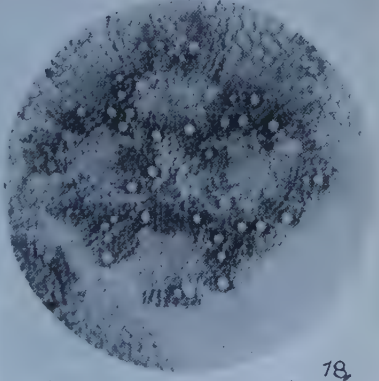
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NOTES ON STRAND PLANTS. II. *CAKILE MARITIMA*, SCOP.
By JAMES WRIGHT, B.Sc.

(Read 16th June 1927.)

Cakile maritima, a member of the Strand Association, is a herbaceous annual of sub-prostrate habit. From a pivot taproot averaging 18 inches in length, the stem branches out in the form of a rosette. Curving upwards, the branches reach a maximum height of from one to two feet and end in ebracteate racemes of lavender-coloured flowers.

The soil in which the plant grows is alkaline (pH 8·6), while the plant sap is distinctly acid (pH 6·4).

STRUCTURE OF VEGETATIVE ORGANS.

The leaves are alternate with sub-erect orientation. Of succulent texture, when adult, they have an oblong outline, deeply serrated margin, and taper to the base. When young, the margin is entire except for two notches flanking the apex. The position of the midrib is indicated by a groove on the under and a ridge on the upper surface.

The epidermis is thinly cutinised, and its cells are not of uniform size. A few cells which project slightly are four to five times the size of the others. At the tip of the young leaf the cells contain anthocyanin, elsewhere they are colourless.

Stomata occur on both surfaces, but are approximately one and a half times as numerous on the under as on the upper surface. The average distribution on the under is 96 per sq. mm., on the upper side 64 per sq. mm. They are flush with the surface and typically cruciferous; that is, in addition to the guard cells they have three auxiliary cells, one of which is smaller than the other two.

This system is due to the manner of division of the stomatal mother-cell, which segments after the fashion of a triangular apical cell. The area occupied by the stomatal apparatus (guard-cells and pore) is ·0007 sq. mm., approximately.

The mesophyll, all the cells of which are chlorophyllous, is undifferentiated. Of compact tissue centrally, it becomes spongiöse peripherally owing to increase in the number of

intercellular spaces. Scattered throughout are idioblasts, secretory-sacs, distinguished by their shape and dark contents.

The leaf-trace is of three meristeles, which leave the stem stele at a distance of two bundles from each other. These, traversing the length of the leaf, end in three hydathodes, situated at the leaf-apex and the two flanking teeth, previously referred to. These hydathodes are on the abaxial side of the leaf-apex and are sub-marginal. Each consists of a small elevated patch of thin-walled cells containing four pores and a hypodermal epithema communicating with the brush-like end of the meristele. The three meristeles give off branches singly on alternate sides and a reticulum is formed.

The elements of the xylem are spiral tracheids and parenchyma, of the phloem, long tubular elements without sieve-plates, but chiefly of parenchyma.

The stem, green and with smooth surface, is circular in cross-section. The outer and inner walls of the epidermal cells are strongly thickened, that of the former is 7.5μ , with a cuticle 2.5μ , while the inner is 5μ in thickness. Giant cells occur as in the leaf; these, like the other epidermal cells, are clear and colourless. The stomata are similar to those of the leaf, but the distribution is only 36 per sq. mm., and the area of stomatal apparatus is $.00096$ sq. mm. The hypodermis is one cell deep, and is composed of thin-walled, spherical, colourless cells. Internal to this is the chlorophyllous tissue, a layer of spherical cells, three cells deep, with large intercellular spaces.

The inner cortex is of thin-walled parenchyma. Idioblasts similar to those in the leaf are of common occurrence. The vascular cylinder is a medullated monostele of open collateral bundles enclosing a large parenchymatous pith.

The primary xylem is composed of spiral vasa, the secondary of bordered-pitted tracheae and woody fibres with simple pits.

The phloem elements, which show radial arrangement, are sieve-tubes, companion-cells, and parenchyma.

Secondary growth is on normal lines. As thickening proceeds, strands of bast fibres are formed external to the primary phloem by a few parenchyma cells, increasing in length by sliding growth and their walls becoming lignified.

The primary root exhibits the following tissues:—Piliferous layer, parenchymatous cortex, endodermis, rich in starch, and

a diarch non-medullated stele. The pericycle, of thin-walled cells, is two cells deep. There is no epi-endodermal network, that feature which, according to Solereder ((6) vol. i, p. 66), quoting from Van Tieghem, is a common feature of some members of the order.

Secondary thickening is initiated very early, the stelar and cork cambiums becoming active almost concurrently, the former only slightly ahead of the latter. The phellogen, of pericyclic origin, produces the usual tissues of the phellem and phelloderm. Owing to early decortication, roots, even after secondary growth has been established, may have a diameter of only 180 to 200 μ . The stelar cambium, originating as two crescents between the central xylem-plate and the primary phloems, gives two arcs of secondary xylem and phloem. As in the stem, bast fibres are developed at a later stage at the outer limits of the primary phloem. Two primary rays are formed by general division of pericyclic cells, while in older roots additional rays are formed by the cambium. These are parenchymatous, two or three cells wide, and of depth varying from six to twenty-four cells.

The primary xylem is of reticulate vasa, the secondary of pitted tracheae. The constituent elements of the primary phloem are sieve-tubes and companion-cells, while the secondary is mainly parenchymatous with a few isolated sieve-tubes.

Bacterial zoogloae were found in the secondary xylem of all the roots examined, but the history of these was not worked out.

FLOWER, FRUIT, AND SEED.

The flowers are regular, hexacyclic, and hermaphrodite, and in dimensions half an inch in diameter. They have the general cruciferous structure, but exhibit certain peculiarities in the gynaecium.

The latter is tetracarpellary and syncarpous. The carpels, forming one whorl, are not all identical. The sessile stigma is of two hemispherical segments, situated antero-posteriorly, each with a slight groove along the middle line. In longitudinal tangential section the segment is bilobed. It is of parenchyma, fringed with stigmatic hairs.

The lateral carpels are leaf-like in form, with prominent mid-rib and reticulate venation of the pinnate type. The

vascular supply of these carpels has no connection with the stigma.

The median carpels are much reduced, and have a double central strand of vascular tissue with very scanty branching. At the apex the twin bundles diverge and they are continued upwards into the stigmatic lobes. The position of the lobes is in relation to the endings of these vascular bundles.

On their inner aspect these carpels develop strongly, centripetally forming ingrowths which, meeting, fuse and form the median vertical septum. The latter is three cells deep, thinning off to one cell at the line of fusion.

It is the median carpels which bear the ovules. On each side of the median septum the primordium of an ovule develops at the middle region of the carpels.

So far as the carpels are concerned there is thus division of labour. The lateral carpels differ from the median both in morphology and physiology. The structure is consistent with the "Polymorphic Carpel View" of E. Saunders ((4) p. 122). The laterals are "hollow," the medians are "solid" carpels.

Of ovules the anticipated number is four. In every case, however, the left posterior does not develop beyond a primordial stage of about half a dozen cells covered by dermatogen. The three remaining primordia develop into campylotropous ovules. The right posterior and the left anterior turn upwards, while the right anterior grows downwards.

These ovules, increasing in size, exert a mechanical pressure on the median septum and distort it. It becomes sinuous in vertical section and arc-shaped in transverse section, assuming the contours of the parts of the ovules pressing against it. The left anterior is usually crushed out of existence. In 5 per cent. of the cases examined the right anterior does not mature. This would seem to be due to chance non-fertilisation, and might be accounted for by the distance of the micropyle from the stigma. In these instances the left anterior is allowed space to develop and matures into seed. Thus the seed output is constant at two, though there is variety in the ovules maturing.

After fertilisation there is a new development. A layer of meristem arises in the lateral carpels at the level of the ovuliferous region, interrupting the vascular supply. By its activity the carpels are increased in thickness, forming an incomplete

transverse dissepiment in the median transverse plane, and thus laying the foundation of a lomentaceous fruit. There is no fusion, so no real transverse septum is formed. In the meantime the longitudinal septum dries off and is represented by a thin papery membrane in the mature fruit.

In autumn, in the mature fruit, fragmentation readily occurs in the line of the meristem strip. The lower segment is not dispersed, but dehisces in situ while the detached segment dehisces on the ground. The line of dehiscence is along the middle region of the solid carpels. In many cases the partial fruit is not dehisced.

The seed is flattened in the vertical median plane and has average dimensions of 8 by 4 by 2 mm. The testa is smooth, brown, and two-layered. The outer layer is sclerenchymatous, the inner of regular prismatic cells with very dense contents and mucilaginous walls. The seed is exendospermic, and the embryo, which completely fills the interior, is pleurorhizal with accumbent radicle. Reserves of protein and oil are generally distributed in the axis and the cotyledons.

SECRETORY TISSUES.

Secretory-sacs, characteristic of the order, are found in all the organs of the plant, vegetative and floral. The contents give a strong protein reaction, and the sacs were shown by Guignard ((3) p. 249 *et seq.*) and Spatzier ((7) p. 39 *et seq.*) to be centres for the formation of myrosin, a glucoside-splitting enzyme, characteristic of the family. The sacs vary considerably in dimensions and may occur isolated, or several may be in contiguity.

When among assimilatory tissue, the sacs contain chloroplasts more numerous but smaller and paler than elsewhere. Schweidler ((5) pp. 281 and 283) places the Cakilinae in his class Exo-idioblastae, *i.e.* the secretory cells are found only in the mesophyll, but *Cakile maritima* does not conform to this type, since they occur not only in the mesophyll but elsewhere, including the vascular system of the root. It is referable rather to his type Hetero-idioblastae.

In locating the sacs the reagents of Guignard (*loc. cit.*) were used, viz. Millon's Reagent, and Orcin and HCl. These were supplemented by the following:—Diazobenzolsulphonic

acid, Sulphuric acid, and Iodine, used by Spatzier (*loc. cit.*), and also Chlor-zinc-iodine, Iod-chloral, KOH.

Except for the difference mentioned above, the topographical distribution of the sacs in this species corresponds to that given by Schweidler (*loc. cit.*) for the Cakilineae in general.

1. In the primary root, they are met with in the cortex; in older roots, in the pericycle and phloem; and in the oldest, in the secondary phloem-parenchyma.

2. In the stem, they are localised chiefly in the assimilatory region of the cortex, where they are long and tubular, with dimensions $300 \times 25 \mu$, contrasting with the ordinary cells, which are roughly spherical, 45μ in diameter. A few idioblasts also occur in the inner cortex contiguous to the stele. Here the ordinary cell is of dimensions $80 \times 40 \mu$, while the secretory-sacs are $550 \times 15 \mu$ in measurement. In the stem, acropetally, the myrosin sacs increase in number.

3. Sacs occur in the mesophyll, principally located towards the under surface of the leaf. The mesophyll cells are roughly isodiametric (40 to 50μ diam.), while the myrosin sacs are elongated and tubular, varying from 100 to 200μ in length and from 25 to 30μ in diameter.

4. In the sepals and petals, the myrosin sacs are very abundant, but larger in the former than in the latter. In both instances they are tubular, and occur among the parenchyma. In the sepals their dimensions are 100 to 550μ in length and 25 to 45μ in width, while the parenchyma cell has magnitude $75 \times 25 \mu$. In the petals their average size is 80 to 120μ by 20μ in width; the parenchyma cells are isodiametric (10μ).

5. The carpels contain a rich supply. Here there is great variability in size, from units 40μ in diameter, isodiametric, resembling the parenchyma cells, to long tubular elements $1000 \times 40 \mu$ in dimensions. Guignard (*loc. cit.*) states that they are located in the tissue adjacent to the vascular bundles, but in the species under consideration they are, on the contrary, most numerous towards the periphery, *i.e.* the lower surface of the carpel, a distribution which corresponds to that in the ordinary leaf.

6. The seed, too, is well supplied. The sacs are isodiametric and the myrosin is in the form of granules resembling aleurone grains (in contrast to the condition in the other organs, where

it is in aqueous solution unless in alcoholic preparation). The cells of the inner mucilaginous layer of the testa are crammed with the grains and appear to contain little else. In the embryo, the myrosin cells are found in the parenchyma of the cotyledons and in the cortex of the axis.

Sinigrin, Potassium myronate, the glucoside hydrolysed by myrosin, is found in all the organs, vegetative and floral. It is contained in the ordinary parenchyma cells distinct from the myrosin sacs. Its presence was determined by Guignard's method, *i.e.* by adding an aqueous solution of myrosin to sections cleared of the ferment and of fatty material by prolonged soaking in absolute alcohol. In every case the characteristic odour of Allyl isothiocyanate was recognisable after a short time. It was evolved soonest and was strongest in the root. Microchemical tests with Tincture of Alkanna, diluted with water, showed the glucoside to be present in greatest abundance in this organ.

THE SEEDLING.

Seeds were collected in October and an attempt made to germinate them in spring. Some were placed in a germinator at 25° C., others in a cool frame, but of all only 5 per cent. showed viability. The embryos were dissected out of several seeds and immersed in Dieterich's nutrient medium, and though all showed signs of life, this again was unsuccessful.

In October, plants, of which the fruits were still intact, were taken from the strand and transplanted on a sand mound in the Botanic Garden. Towards the end of March a crop of about 20 seedlings appeared on the mound. Material was also collected in the natural habitat where large crops of seedlings made their appearance about the same time.

In the autumn, seeds and partial fruits, not yet dehiscent, are buried by the moving sand, and lower indehiscent partial fruits are buried along with the old plants. The seeds and fruits lie all winter, one to three inches below the surface, and at this depth germination takes place and the pericarps of the indehiscent fruits are now ruptured by the germinating seed. Germination is epigeal.

As previously pointed out, there is variety in the maturation of the ovules, and this results in three kinds of partial fruits.

Cases were observed where the seedlings appeared through the pericarp of upper and lower partial fruits, as also where the two seedlings were growing together through the pericarp of an upper partial fruit in which the two ovules had matured to seed.

The dimensions of the fruit coat give stability to those seedlings.

There is an interesting distinction between seedlings developing from seed which has germinated near the surface and those from seed which has been more deeply buried, noticeable even when the seeds are still enclosed in the pericarp. In the latter case, the seedling is stabilised by the elongation of its hypocotyl and its primary taproot immersed in the sand; in the former, it early secures stability by the production of an abundant crop of adventitious roots developing from the base of the hypocotyl. The seedling is erect, the hypocotyl cylindrical, varying in length, as described, according to the depth at which the seed has germinated. Where exposed to the light it has developed anthocyanin, elsewhere it is colourless. The anthocyanin is located in the hypodermal cells, and also in the cells of the cortical layer immediately adjacent to the stele.

The green cotyledons, oriented horizontally, are fleshy, linear, obtuse, sessile, with entire margins and tapering to the base. The hypodermal cells at the apex, immediately above the midrib, contain anthocyanin.

VASCULAR ANATOMY OF SEEDLING.

(a) Nine days old. Text-figure 1.

The primary diarch root has a central xylem plate flanked by two arches of phloem (fig. 1). This system is continued towards the collet, where changes take place. Two diagonal protrusions originate from and at right angles to the metaxylem plate (fig. 2). This is followed by a second similar pair of outgrowths, parallel to and on opposite sides from the first, and the metaxylem in consequence assumes a rectangular outline in T.S. (fig. 3). Medullation begins in this rectangle and proceeding centrifugally, at right angles to the cotyledonary plane, divides the xylem into two segments (fig. 4). This is followed by a corresponding division of the two phloem

patches and the formation of two primary medullary rays (fig. 5). The four phloem groups begin to rotate outwards, and

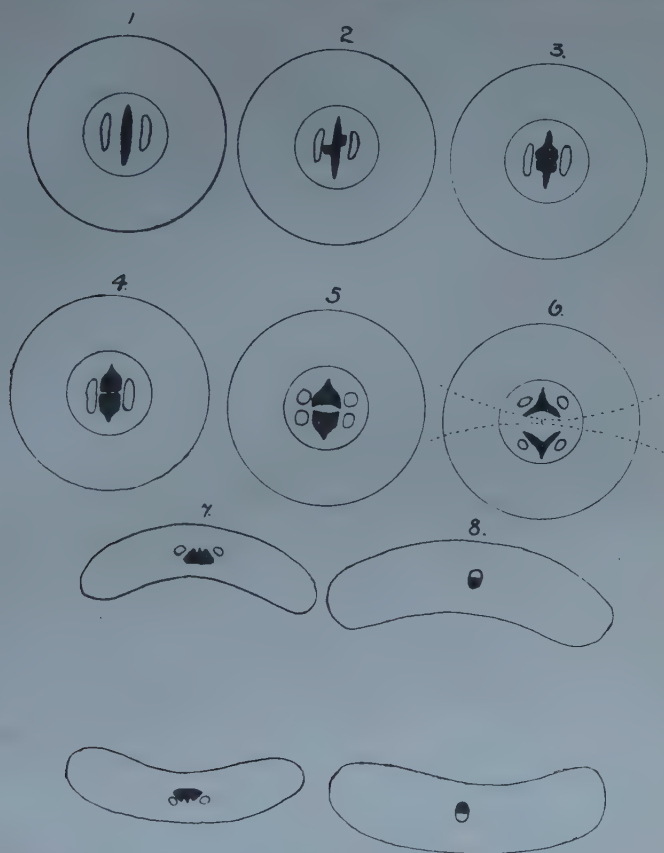


FIG. 1.—Serial diagrams illustrating transition stages in the nine days old seedling. (Xylem, black; Phloem, outlined.)

1. Primary diarch root. 2. Two diagonal xylem protrusions. 3. Two protrusions in opposite direction. 4. Medullation. 5. Division of phloem and formation of two primary rays. 6. Further medullation of xylem and commencement of rotation of phloems. 7. Triad structure of meristele in base of cotyledon. 8. Fusion of phloem and disappearance of protoxylem to give collateral meristele in upper part of cotyledon.

concurrently the metaxylem undergoes further medullation from the centre in the cotyledonary plane until each of the xylem groups has assumed a Y-shaped configuration in T.S. (fig. 6).

On the flanks of each xylem strand opposite the phloem, fresh xylem is formed, and the protoxylem becomes somewhat crushed. The xylem thus enlarged and flanked by the two phloem strands, passes into the cotyledon as a median meristele (fig. 7), and here the final transition is effected. The phloems continue to rotate until they have completed an angle of 90° and are in contiguity. *Pari passu*, the protoxylem disappears, and thus in the upper part of the cotyledon complete transition to a single collateral bundle is effected.

This transition corresponds to Type III of Van Tieghem ((9) pt. 1, p. 782), the phloems rotating while the xylems remain fixed. It is the Diarch Cruciform Type described by Thomas ((8) pp. 698, 714, and 730), and the details correspond with those observed by her in *Cheiranthus cheiri* and by Chauveaud ((1) p. 327) in *Raphanus sativus*. The transition takes place slowly in the hypocotyl above the collet, and, as it is incomplete at the cotyledonary node, it conforms to the "High" type of Compton ((2) p. 66), who has worked out the seedling structure of Leguminosae.

(b) One month old. Text-figure 2.

The initial stages of the transition are identical with those observed in the younger seedling, but are somewhat masked by secondary growth. They take place over four-fifths of the length of the hypocotyl, and at this level there is a commencement of a further series of changes. In each of the primary medullary rays a cauline bundle appears, demarcating four rays (fig. 1).

Four additional bundles are developed leading to the demarcation of eight rays (fig. 2), in each of which a bundle again develops, giving sixteen in all, forming in T.S. an elliptical stele (fig. 3). Above this level the stele assumes a sinuous outline due to the departure from it of the two compound bundles accompanied on either side by a lateral. These laterals belong to the last-formed series of eight, and are separated from the primary double bundle by two bundles of different ages, one of the same, the other of an older series (fig. 4).

The laterals pass out from the stem stele ahead of the primary double bundles and course up in the cortex, sometimes branching (fig. 5) into the base of the cotyledons (fig.

6). The cotyledonary trace now differs from the trace in the adult leaf only in the central meristele. It has still the triad

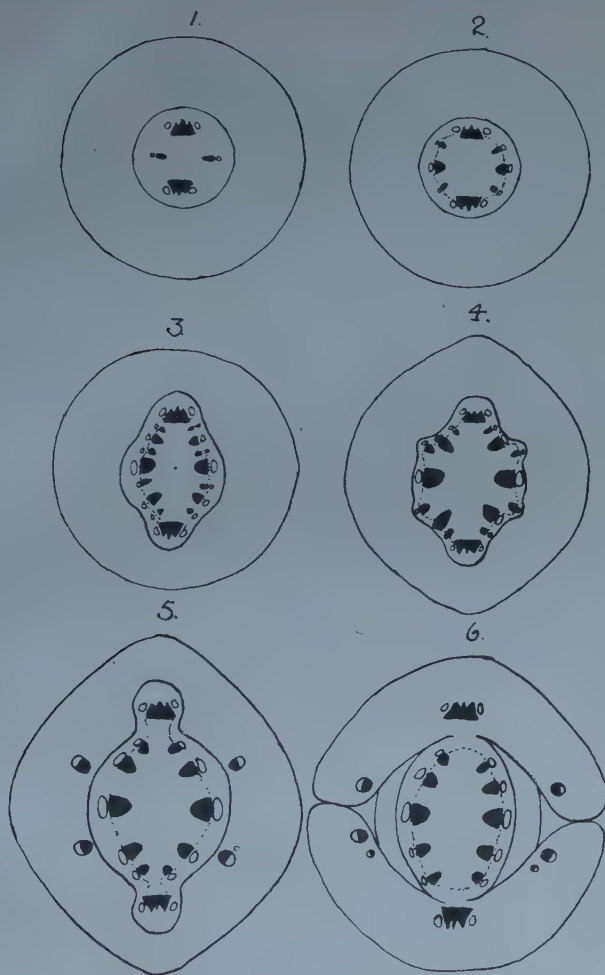


FIG. 2.—Month old seedling.

1. T.S. at one-fifth length of hypocotyl from the cotyledonary node to show appearance of cauline bundles. 2. Appearance of four additional bundles. 3. Sixteen bundles. 4. Departure of cotyledonary bundle and laterals from the stele. 5. Course of laterals in the cortex. 6. Triad structure, and two laterals in base of cotyledon; ring of ten bundles passing upwards into the plumule.

structure as in the young seedling, and, as in the latter, the complete change is effected in the passage up the cotyledon.

The stele, consisting of a ring of ten bundles, linked up by a cambium, continues onwards into the plumule (fig. 6).

SIGNIFICANCE OF THE PLANT IN DUNE-FORMATION.

The plants grow on mounds, varying in height from one to three feet, with an average of two feet.

The junction of root and stem, however, is approximately one foot below the surface level of the mound, and the origin of the deepest adventitious root about two and a half feet down. At a depth of two feet below the surface decaying remains of old plants are found.

The process of mound formation is as follows: A plant arises from seed and establishes itself, and thereafter by the action of wind and tide sand is heaped up on its seaward side. In autumn the plant sheds the upper partial fruits, some of which drift away while others remain where they have fallen. During the high tides of late autumn the old plant is buried, and with it the lower partial fruits, some of which have not dehisced, and any upper partial fruits and seeds which are lying near. The seeds germinate in spring in a substrate stabilised by the remains of the old plants. We have seen that in some instances the seed germinates in the lower partial fruit which is still attached to the old plant, thus further adding to the stability. A few seedlings survive in the struggle for existence on the mound, and the process of the previous year is repeated at a slightly higher level. Sand is heaped higher and higher on the seaward side, and so the mound increases in magnitude. Sometimes seeds of *Psamma arenaria* and *Elymus arenaria* germinate on the seaward side of the mound, and the young plants so originating play their part in the work of stabilisation and enlargement of the small dune.

In other cases the mounds originate, *ab initio*, from the united action of all three species which have been growing in contiguity.

The writer has to express his indebtedness for facilities and assistance afforded him in the Botanical Department, St Andrews University, where this investigation was carried out.

SUMMARY.

1. The anatomy of *Cakile maritima* exhibits no very anomalous features. The leaves have large stomata which are unprotected; apical hydathodes are present; secondary growth is initiated very early in the root.

2. The gynaeceum in structure conforms to the polymorphic type of Saunders.

3. Of four ovular primordia laid down, one always atrophies early, and only two of the remaining three mature to seed.

4. By the activity of a secondary meristem in the "hollow" carpels, an imperfect transverse septum is formed at which fragmentation of the lomentum occurs.

5. Frequently the partial fruit remains indehiscent and the seed or seeds germinate in situ.

6. Myrosin sacs occur in the parenchyma of the vegetative and floral organs, but in the stelar tissues only in the pericycle and secondary phloem of the root.

7. Sinigrin is localised in the same regions but in the ordinary parenchyma cells, distinct from those containing the enzyme.

8. The development of the hypocotyl and root in the seedling varies with the depth at which germination of the seed takes place.

9. The hypoderma and innermost cortical layer of the hypocotyl contain anthocyanin. It also occurs in the apex of the cotyledon immediately above the midrib.

10. The transition stages in the vascular tissue of the young seedling correspond to the Cruciform Diarch Type of Thomas.

11. This is constant in the older seedling, but further in the upper fifth of the hypocotyl a ring of bundles is formed, four of which become laterals to the double cotyledonary bundles.

12. *Cakile maritima* is of some importance in stabilising the soil in the early stages of dune-formation.

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HARD SEEDS AND BROKEN SEEDLINGS IN RED CLOVER
(*Trifolium pratense*). III. SOIL EFFECTS. By ALEXANDER
NELSON, B.Sc., Ph.D. (With Pl. XVIII.)

(Read 16th June 1927.)

Introduction.—In papers already published (4, 5), Hard Seeds and Broken Seedlings, abnormalities which commonly occur in germination tests of red clover and other legumes, have been described and certain aspects of their behaviour noted. Briefly, hard seeds have been described as seeds which, when offered ideal conditions for germination, fail to absorb moisture and therefore remain hard and dormant. This inability to absorb moisture is due, not to dormancy of the embryo itself, but to a peculiarity of the seed coat: slight abrasion of the testa permits normal germination to take place promptly. The existence of a clearly defined, structureless cuticle staining yellow with chlor-zinc-iodine has been demonstrated by White (11), and the present writer has suggested (6) its formation by deposition on the surface of the seed from the fluid contents of the maturing pod.

Broken seedlings have been described simply as seedlings which early in their development have broken into two or more pieces. Two types may be recognised: (*a*) Where the break takes place in the hypocotyl itself,¹ leaving two pieces, one consisting of the radicle and a portion of the hypocotyl; the other, including the plumular bud, the cotyledon leaves and a small portion of the hypocotyl (see *a*, fig. 1); and (*b*) where the break occurs at the joint which, as noted by Compton (1), occupies a position between the lamina and the petiole of the cotyledon leaves. This break results in the main axis (radicle, hypocotyl, and plumular bud) being left entire, while the cotyledons are separate and free (see *b*, fig. 1).

In a formal test of any leguminous plant (including red clover) the percentage of hard seeds persisting at the end of the conventional period (usually ten days) is deducted from the percentage declared viable. So, too, is deducted the percentage of broken seedlings which have failed to make good

¹ Compton (1) notes that in the *Trifolieae* the hypocotyl is slender and rather weak.

the injury, as, for example, by the production of adventitious roots by type (*a*). To count as viable a seed must have produced within the period of the test a plantlet composed of a rootlet (primary or adventitious), a bud, and some form of leaf (Saunders (9), Pammer and Schindler (7)). The total deduction may be considerable, and lower proportionately the price receivable for the seed bulk when marketed. These deductions are made because it is believed that hard seeds are of

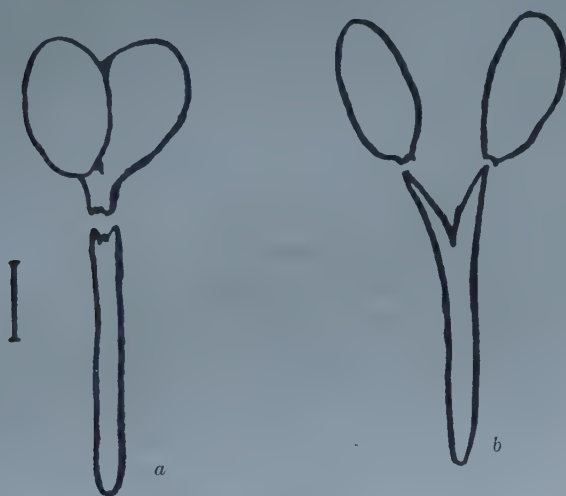


FIG. 1.—Broken seedlings as they occur in artificial tests (diagramised). For description of the two types (*a*) and (*b*) see text. (The natural size of a complete seedling is indicated by the line on the left.)

little value when sown in the soil, while broken seedlings are quite useless. Broken seedlings are ranked with dead seeds (Saunders (9)).

From a desire to know more regarding the behaviour of commercial seed when sown in soil comparative tests were instituted.

Materials and Methods.—Two samples of seed were selected which in recent routine tests had provided the following data regarding their germination:—

No. 1. 87 per cent. grown, 1 per cent. hard, 10 per cent. broken seedlings, and 2 per cent. dead.

No. 2. 66 per cent. grown, 1 per cent. hard, 20 per cent. broken seedlings, and 13 per cent. dead.

Good medium potting soil was firmly pressed into shallow boxes to a depth of 3 inches. From edge to edge of the boxes white cotton thread was stretched so as to divide the surface area of the soil into small squares of $\frac{1}{2}$ inch side. In the centre of each square so delimited a small hole $\frac{1}{2}$ inch deep was made by means of a blunt dib having broad shoulders $\frac{1}{2}$ inch from its distal end. Into each hole a single seed was dropped and firmly covered with soil.¹ After moistening the soil with a fine spray the boxes were kept at room temperature, further waterings being made as required.

Results.—About one week after sowing the seedlings were appearing above ground, and they were allowed to develop for another week in order that the broken seedlings might be clearly recognised. After the fourteenth day from sowing a count was made with the following results:—

No. 1. 75 per cent. normal seedlings, 13·5 per cent. broken seedlings, and 11·5 per cent. blanks.

No. 2. 42 per cent. normal seedlings, 21 per cent. broken seedlings, and 37 per cent. blanks.

Comparison of these figures obtained in soil with those obtained on blotting-paper in an incubator shows that the number of blanks in the soil is greater than the number of “hards” plus dead found in the routine test, and the difference is greater in the case of the poorer of the two samples. This lends support to a conclusion previously stated (5) that some proportion of the seeds proved capable of producing normal plantlets in an artificial test are weak and on the verge of being non-viable.² These, it has been shown, may be killed off by storage under adverse conditions, and, as Pearl and Allen (8) have surmised, by immersion in weak alcohol.

Apparently, too, these weak seeds have not sufficient life in them to withstand the opposition and less kindly conditions experienced in the soil. This is very clearly demonstrated by the work of Stapledon, Davis, and Beddows (10) in the field at Aberystwyth.

The fact that all the broken seedlings developed and made themselves apparent in the soil³ is worthy of emphasis, for it

¹ Williams (12) quotes Findlay as stating that the best depth for sowing red clover is half an inch, and confirms this finding.

² Dorph-Petersen (2) reports a similar result.

³ The figures for broken seedlings in soil and artificial test here reported closely coincide in the case of both samples.

certainly does no violence to the theory previously advanced (5) that they are produced by seeds of rather more than average energy. At this point (fourteen days from sowing) the normal plantlets were pulled out and the behaviour of the abnormal types studied.

Little or nothing was expected from the hard seeds, for, as Harrington (3) has shown, only a small proportion of hard seeds in red clover produce plants in the soil when sown and maintained under moderate conditions of temperature and moisture, though extremes of either condition may bring about complete germination.

The development of the broken seedlings, however, proved to be of the greatest interest. In the case of type (*a*) the stump formed by the primary root and portion of the hypocotyl assumed a vertical position, partly above the soil, and in course of time withered and disappeared, while the cotyledons appeared above the surface of the soil, as shown at *a*, Pl. XVIII. The cotyledons remained fresh, and small adventitious roots were given off from the fractured hypocotyl, just as often happens in routine tests on moist blotting-paper. These adventitious roots became established in the soil, the cotyledons were raised above the surface, and a plant produced which, but for the absence of a primary root, might be taken for a perfectly normal seedling (see A, Pl. XVIII).

In the case of type (*b*), where the break occurs at the stalk of the cotyledons, they, in most cases, were carried up to the surface of the soil, while the main axis assumed a vertical position. Shortly after the fourteenth day from sowing a rough leaf (similar in character to one leaflet of the normal trifoliate leaf)¹ appeared at the tip of the axis (see *b*, Pl. XVIII), and at from twenty to thirty days the first normal trifoliate leaf was produced. In short, these broken seedlings of type (*b*) in every case are quite capable of producing an established though perhaps slightly stunted plant in the soil (see B, Pl. XVIII).

CONCLUSIONS.

It would seem clear that, given not too adverse circumstances for development, the portion of a broken seedling which

¹ This is the leaf produced first after the cotyledons by a normal seedling.

includes the plumular bud is capable of forming a plant when the seed has been sown in the soil. It is specially interesting to note that the type of broken seedling which formal seed analysis regards as of least value (type *b*) is the one most likely to produce a plant. The reason for the current belief that broken seedlings are incapable of forming a plant in the soil appears to have arisen from abortive attempts to establish, in soil, broken seedlings originally produced on blotting-paper pads and other artificial media; normal seedlings do not respond well to that treatment.

The tests here reported were carried out in the Scientific Department of Messrs. David Bell, Ltd., Leith.

The writer is indebted to Miss A. W. Mackie for considerable assistance with the work, and to Mr. R. M. Adam for the photographs which illustrate the paper.

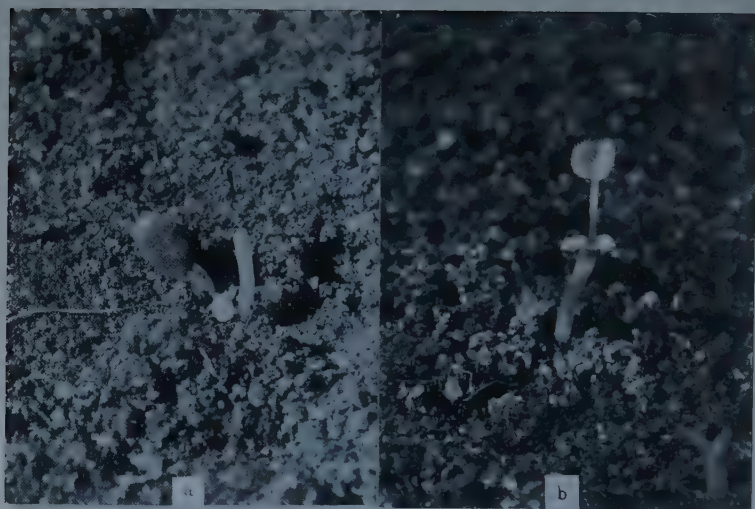
SUMMARY.

Two samples of red clover when sown in soil yielded fewer normal plantlets than when germinated on an artificial medium, *e.g.* blotting-paper such as is used in routine seed analysis. Both samples in soil produced a number of broken seedlings strictly comparable with that found in the artificial test. A high proportion of the broken seedlings resulted in functioning plants.

It is concluded that if the plumular bud is accompanied by any sensible amount of the other portions of the developing embryo a functioning plant results.

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DESCRIPTION OF PLATE XVIII.

- (a) A broken seedling of type *a* as produced in the soil. (Note the plumule appearing between the cotyledon stalks.) $\times 2\frac{1}{2}$.
- (b) A broken seedling of type *b* as produced in the soil. (Note first rough leaf.) $\times 2\frac{1}{2}$.
- (A) An established plant as produced by a broken seedling of type *a*. (Note the absence of a taproot.) $\times 1\frac{1}{2}$.
- (B) An established plant as produced by a broken seedling of type *b*. (Note the absence of cotyledon leaves.) $\times 1\frac{1}{2}$.
- (C) An established plant as produced by a normal seedling. $\times 1\frac{1}{2}$.

ADDITIONS TO THE FLORA OF ORKNEY, AS RECORDED IN
WATSON'S "TOPOGRAPHICAL BOTANY," Second Edition
(1883). By Colonel H. H. JOHNSTON, C.B., C.B.E.,
D.Sc., M.D., C.M., F.R.S.E., F.L.S.

(Read 16th June 1927.)

This paper forms a continuation of nine papers on the same subject, one of which I read before the Scottish Natural History Society on 4th April 1895, and which was published in "The Annals of Scottish Natural History," No. 15, pp. 173-181 (July 1895), and the other eight before the Botanical Society of Edinburgh on 15th January 1914, 10th June 1920, 17th March 1921, 20th April 1922, 19th April 1923, 19th June 1924, 19th June 1925, and 17th June 1926, and which were published in the Society's "Transactions," vol. xxvi, pp. 207-217 (1914); vol. xxviii, pp. 23-42 (1920), pp. 51-66 (1921), pp. 98-117 (1922), and pp. 174-183 (1923); and vol. xxix, pp. 83-95 (1924), pp. 151-170 (1925), and pp. 297-307 (1926), respectively.

Before and after the publication of the second edition of Watson's "Topographical Botany," in 1883, several of the plants mentioned in the following list have been recorded from Orkney by me and other botanists; but as the value of botanical records is greatly enhanced by the possession of authentic specimens, I have included in this list the names of all specimens in my herbarium, which are either additional to, or confirm doubtful records of, the plants recorded from county No. 111 Orkney in the second edition of the above-mentioned book.

In the case of those plants which have already been recorded from Orkney, references are given in the following list, under each species and variety, to the books in which the records have been published. These records are principally contained in "A Tour through some of the Islands of Orkney and Shetland," in the year 1804, by Patrick Neill (1806); "Notice of some of the rarer Plants observed in Orkney during the Summer of 1849," by John T. Syme, Esq., published in the "Transactions of the Botanical Society of Edinburgh," vol. iv, pp. 47-50 (1850); "Florula Orcadensis—A list of

plants reported to occur in the Orkney Isles," by H. C. Watson, Esq., F.L.S., published in "The Journal of Botany," No. xiii, pp. 11-20 (January 1864); Annual Reports of the Botanical Exchange Club of the British Isles; "A new List of the Flowering Plants and Ferns of Orkney," edited by W. A. Irvine Fortescue, and published in "The Scottish Naturalist" (1882-1884); "Supplement to Topographical Botany," ed. ii, by Arthur Bennett, A.L.S. (1905); and "Flora Orcadensis," by Magnus Spence, F.E.I.S. (1914).

The nomenclature followed is that of the second edition of Watson's "Topographical Botany" (1883), except in the case of species and varieties which are not recorded in that work. In the latter case the nomenclature adopted is that of the "London Catalogue of British Plants," eleventh edition (1925), except where otherwise stated. Non-native plants, which have become naturalised in Orkney, are distinguished by a * prefixed to the names, and the names of casuals are printed in italics.

Of the 21 species, varieties, forms, and hybrids recorded from Orkney in the following list, 19 are native, and 2 are mere casuals introduced into Orkney through the agency of cultivation.

ABBREVIATIONS.

"Annals Scot. Nat. Hist."=The Annals of Scottish Natural History.
Bennett, "Suppl. Top. Bot."=Supplement to H. C. Watson's Topographical Botany, second edition. By Arthur Bennett, A.L.S. (1905).

"Bot. Exch. Club Report" (separate Reports by the Secretary and Distributor)=Report of The Botanical Exchange Club of the British Isles, at present called The Botanical Society and Exchange Club of the British Isles.

"Journ. Bot."=The Journal of Botany.

"Lond. Cat."=The London Catalogue of British Plants.

Neill, "Tour"=A Tour through some of the Islands of Orkney and Shetland, in the year 1804. By Patrick Neill, A.M., Secretary to the Natural History Society of Edinburgh (1806).

"Scot. Nat."=The Scottish Naturalist.

Spence, "Flora Orcadensis"=Flora Orcadensis. By Magnus Spence, F.E.I.S. (1914).

Watson, "Top. Bot."=Topographical Botany, second edition. By H. C. Watson (1883).

CORRECTIONS.

In "Trans. Bot. Soc. Edin.," vol. xxviii, part i, p. 27 (1920), for "CERASTIUM SUBTETRANDRUM, *Murbeck* (*fide* Arthur

Bennett)," read *CERASTIUM TETRANDRUM*, *Curtis*, and, in lines 20-22 from top of page, *delete* "A new record for H. C. Watson's county No. 111 Orkney."

Note.—Mr. C. E. Salmon, in a note on specimens of *CERASTIUM* collected by me (Henry Halero Johnston) in Orkney, dated 16th October 1925, writes as follows :—"Reference Nos. 673, 677, 683, 770. Murbeck will not pass the above as his *C. SUBTETRANDRUM* but calls them all *C. TETRANDRUM*. If he is right in placing them under the latter, they seem to be a variety which deserves a name"; and, in a letter to me, dated 1st January 1926, Mr. C. E. Salmon writes as follows :—"As regards *C. SUBTETRANDRUM*, I suppose it would not do, in face of Murbeck's determination, to call any of your Orkney plants this." All specimens bearing the following Reference Nos., and distributed by me under the name of "*CERASTIUM SUBTETRANDRUM*, *Murbeck*" (*fide* Arthur Bennett, C. E. Salmon, or E. G. Baker), should, therefore, be renamed *CERASTIUM TETRANDRUM*, *Curtis*, namely, Reference Nos. 400, 637, 640, 659, 670, 673, 677, and 683. Reference No. 770 was not named until the specimens were seen by Dr. S. Murbeck.

In "Trans. Bot. Soc. Edin.," vol. xxvi, p. 209 (1914), for "*ROSA GLAUCA*, *Vill.*, *var. CRÉPINIANA* (*Déségl.*) (*fide* J. G. Baker)," read *ROSA MOLLIS*, *Smith*, *var. a. TYPICA*, *Wolley-Dod*, *form* β . *GLANDULOSA*, *Wolley-Dod*, in his "The Roses of Britain," p. 76 (1924) (*fide* A. H. Wolley-Dod, May 1926); and in "Trans. Bot. Soc. Edin.," vol. xxviii, part i, p. 25 (1920), lines 15-17 from top of page, *delete* 'and for "*ROSA GLAUCA*, *Vill.*, *var. CRÉPINIANA* (*Déségl.*) (*fide* J. G. Baker)," read *ROSA TOMENTOSA*, *Sm.* (*fide* W. Barclay).' [The same correction should be made in Magnus Spence's "Flora Orcadensis," p. 129 (1914).]

In "Trans. Bot. Soc. Edin.," vol. xxviii, part iii, p. 104 (1922), for "*ROSA OMISSA*, *Déségl.*, *var. b. RESINOSOIDES*, *Crépin* (*fide* William Barclay)," read *ROSA MOLLIS*, *Smith*, *var. a. TYPICA*, *Wolley-Dod*, *form* β . *GLANDULOSA*, *Wolley-Dod*, in his "The Roses of Britain," p. 76 (1924) (*fide* A. H. Wolley-Dod, May 1926). [The same correction should be made in "Bot. Exch. Club Secretary's Report for 1923," vol. vii, part i, p. 183 (November 1924).]

In "Trans. Bot. Soc. Edin.," vol. xxviii, part iii, p. 105 (1922), for "*ROSA GLAUCA*, *Vill.*, *var. c. SUBCANINA*, *Christ* (*fide* William

Barclay)," read *ROSA GLAUCA*, Vill., var. *e. DENTICULATA*, R. Keller (fide A. H. Wolley-Dod, 25th November 1925). [The same correction should be made in "Bot. Exch. Club Secretary's Report for 1923," vol. vii, part i, p. 182 (November 1924).]

In "Annals Scot. Nat. Hist.," No. 15, p. 178 (July 1895), and in a corrected Reprint of pp. 173-181 of that magazine, p. 7 (1st January, 1925), for '*HIERACIUM AURATUM*, Fries, "Sym. Ad Hist. Hieraciorum," p. 181, 1848 (fide F. J. Hanbury),' read *HIERACIUM INULOIDES*, Tausch., subsp. *STRIATUM*, Tausch., var. *b. PSEDAURATUM*, Zahn (fide J. Roffey, who saw all my herbarium specimens on 15th November 1926). [The same correction should be made in Magnus Spence's "Flora Orcadensis," p. 42 (1914).]

In "Trans. Bot. Soc. Edin.," vol. xxvi, p. 223 (1914), for "*P. PECTINATUS*, Linn.," read *POTAMOGETON FILIFORMIS*, Pers. \times *PECTINATUS*, Linn.

CLASS I.—DICOTYLEDONS.

CARDAMINE PRATENSIS, Linn., var. *UNIFLORA*, Sternberg et Hoppe, in "Deutsche Botanische Gesellschaft" (Berlin), vol. i, p. 157, tab. 2 (1815). [= *CARDAMINE ACAULIS*, Borg. (1856)] (fide Arthur Bennett, who saw another specimen of the same gathering in the herbarium of the late Mr. Magnus Spence, now in the Museum of the Orkney Natural History Society at Stromness, on 21st January 1920).—Marshy, muddy bed of a partially dried-up pond, 50 feet above sea-level, Boys' Sailing Pond, above old Filter Tanks, Papdale Burn, Kirkwall, Mainland, Orkney, April 1916, Robert Rendall. Native. Rare. Plants sparingly in flower. A new record for this variety for H. C. Watson's county No. 111 Orkney, discovered by Mr. Robert Rendall in April 1916.

ROSA MOLLIS, Smith, var. *a. TYPICA*, Wolley-Dod, form β . *GLANDULOSA*, Wolley-Dod, in "Journ. Bot.," vol. lxii, p. 208 (1924) (fide A. H. Wolley-Dod, who saw all my dried specimens in May 1926).—Banks at burnside, 15 feet above sea-level, Cairston Mill Burn, Garson, Stromness, Mainland, Orkney, 30th August 1912 (plants in unripe fruit), H. H. Johnston, native, rare; and grassy banks at burnside, 100 feet above sea-level, Trumland Burn, Rousay, Orkney, Reference No.

1422, 25th August 1921 (plants in unripe fruit), H. H. Johnston, and 7th November 1921 (specimens in ripe fruit from the same clump of plants as my Reference No. 1422), John Logie, native, rare. A new record for this form for H. C. Watson's county No. 111 Orkney, discovered by me (Henry Halcro Johnston) on 25th August 1921. See CORRECTIONS, page 410 of this paper, where it is shown that my specimens from Cairston Mill Burn were erroneously identified as "*ROSA GLAUCA*, Vill., var. *CRÉPINIANA* (Déségl.)," by the late Mr. J. G. Baker, and as "*ROSA TOMENTOSA*, Sm.," by the late Mr. William Barclay; and that the specimens from Trumland Burn were erroneously identified as *ROSA OMISSA*, Déségl., var. *b. RESINOIDES*, Crépin," by the late Mr. William Barclay.

ROSA OMISSA, Déséglise, var. *a. TYPICA*, R. Keller, in Asch. and Grabn. "Syn. Mitteleur. Fl.," vol. vi, part i, p. 76 (1900) (*fide* A. H. Wolley-Dod, who saw all my dried specimens on 5th November 1926).—Grassy banks at burnside, 50–65 feet above sea-level, left (north) bank of Wideford Burn, Saint Ola, Mainland, Orkney, (1) Reference No. 3217, 9th October 1925 (specimens in ripe fruit), (2) Reference Nos. 3424 and 3425, 22nd July 1926 (plants in young unripe fruit and sparingly in flower), (3) Reference Nos. 3513, 3514, 3515, and 3516, 16th September 1926 (plants in ripe fruit), H. H. Johnston. Native. Rare. Grassy top of sea-cliffs, 20 feet above sea-level, Established Church Glebe, Bay of Creekland, Hoy, Orkney, (1) Reference Nos. 3234 and 3235, 2nd November 1925 (plants in ripe and unripe fruit), (2) Reference Nos. 3403 and 3404, 14th July 1926 (plants in full flower), and (3) Reference Nos. 3523, 3524, and 3525, 22nd September 1926 (plants in ripe and unripe fruit), H. H. Johnston. Native, common; and Reference No. 3531, grassy banks at roadside, 30 feet above sea-level, Mill Burn, Hoy, Orkney, 24th September 1926 (plants in ripe fruit and sparingly in unripe fruit), H. H. Johnston. Native. Rare. A new record for this variety for H. C. Watson's county No. 111 Orkney, discovered by me (Henry Halcro Johnston) on 9th October 1925.

ROSA DUMETORUM, Thuill., var. *a. TYPICA*, Wolley-Dod, form *γ. SEMIGLABRA*, Wolley-Dod, in his "The Roses of Britain," p. 50 (1924) (*fide* A. H. Wolley-Dod, who saw all my dried specimens of Reference Nos. 3226 and 3229 on 25th November 1925, and all my dried specimens of Reference Nos. 3406,

3407, 3528, 3529, and 3533 on 5th November 1926, and named them all as above on 3rd April 1927):—Heathery, grassy banks at burnside, 100 feet above sea-level, The Glen, Rackwick, Hoy, Orkney, (1) Reference No. 3226, 29th October 1925 (plants in unripe fruit), and (2) Reference No. 3533, 27th September 1926 (plants in unripe fruit), H. H. Johnston, native, rare; and grassy banks at burnside, 30–40 feet above sea-level, Kirk Burn, Bu, Hoy, Orkney, (1) Reference No. 3229, 30th October 1925 (plants sparingly in unripe fruit), (2) Reference Nos. 3406 and 3407, 14th July 1926 (plants in full flower), and (3) Reference Nos. 3528 and 3529, 23rd September 1926 (plants in unripe fruit), H. H. Johnston, native, common. A new record for this form for H. C. Watson's county No. 111 Orkney, discovered by me (Henry Halcro Johnston) on 29th October 1925. The type of the species and variety has not been recorded for Orkney.

Dr. R. Keller, who saw a dried specimen of each of my Reference Nos. 3226 and 3533 from one plant, Reference No. 3528 from a second plant, and Reference No. 3529 from a third plant, on 5th February 1927, determined them all as allied to *ROSA CANINA*, *Linn.*, *var. TRANSITORIA*, *R. Keller*, *form HISPIDULOIDES*, *Schwertscherlager* [= *ROSA CANINA*, *Linn.*, *var. b. INSIGNIS*, *Rouy*, of A. H. Wolley-Dod's "The Roses of Britain," p. 33 (1924), according to Lieutenant-Colonel A. H. Wolley-Dod in a written note to me, dated 14th March 1927].

ROSA GLAUCA, *Vill.*, *var. e. DENTICULATA*, *R. Keller*, of A. H. Wolley-Dod's "The Roses of Britain," p. 61 (1924) (*fide* A. H. Wolley-Dod, who saw all my dried specimens of Reference Nos. 1497, 1543, 3150, 3220, and 3221 on 25th November 1925, and all my dried specimens of Reference Nos. 3438, 3478, 3530, and 3536 on 5th November 1926).—Grassy banks at burnside, 250 feet above sea-level, Burn of Russadale, Upper Dowscarth, Stenness, Mainland, Orkney, (1) Reference No. 1497, 27th September 1921 (plants in unripe fruit), (2) Reference No. 1543, 11th November 1921 (plants sparingly in ripe fruit), (3) Reference No. 3150, 4th August 1925 (plants in flower and unripe fruit), and (4) Reference No. 3221, 22nd October 1925 (plants in ripe and unripe fruit), H. H. Johnston. Native. Rare. Grassy banks at burnside, 200 feet above sea-level, Burn of Russadale, Dowscarth, Stenness, Mainland, Orkney, 22nd October 1925 (plants in unripe fruit), H. H.

Johnston. Native. Rare. Reference No. 3438, grassy banks at burnside, 100 feet above sea-level, Hullion Burn, Rousay, Orkney, 27th July 1926 (plants in unripe fruit), H. H. Johnston. Native. Common. Reference No. 3478, grassy rocky crags on hillside, 470 feet above sea-level, south-west side of Ward Hill, Rousay, Orkney, 31st July 1926 (plants moderately in unripe fruit), H. H. Johnston. Native. Rare. Reference No. 3530, grassy banks at burnside, 35 feet above sea-level, Kirk Burn, Bu, Hoy, Orkney, 23rd September 1926, H. H. Johnston. Native. Rare; and Reference No. 3536, grassy heathery banks at burnside, 120 feet above sea-level, The Glen, Rackwick, Hoy, Orkney, 24th September 1926 (plants in ripe fruit and sparingly in unripe fruit), H. H. Johnston. Native. Rare. A new record for this variety, belonging to Group ii, SUBCANINAE of *ROSA GLAUCA*, *Vill.*, for H. C. Watson's county No. 111 Orkney, discovered by me (Henry Halcro Johnston) on 27th September 1921. The late Mr. William Barclay named my specimens of Reference Nos. 1497 and 1543 as "*ROSA GLAUCA*, *Vill.*; *var. SUBCANINA*, *Christ.*," on 6th March 1922, but Lieutenant-Colonel A. H. Wolley-Dod, in a note on the same specimens, dated 25th November 1925, writes as follows:—"I think it is not SUBCANINA (which Christ described as a variety of *ROSA REUTERI*, *Godet*, not of *ROSA GLAUCA*, *Vill.*), since it is more or less biserrate." See CORRECTIONS, page 410 of this paper. Dr. R. Keller, who saw a dried specimen of each of my Reference Nos. 3438, 3530, and 3536, on 5th February 1927, determined them all as allied to *ROSA AFZELIANA*, *Fries*, *subsp. R. SUBCANINA*, *Hayek*, *var. DENTICULATA*, *R. Keller*, *form SUBGLOBOSA*, *R. Keller*.

LEONTODON AUTUMNALIS, *Linn.*, *var. c. SORDIDUS*, *Babington*.—Reference No. 3191, grassy sea-cliffs, 15 feet above sea-level, between Lee Craig and Stanger Head, Flotta, Orkney, 14th September 1925 (plants in flower and fruit), H. H. Johnston. Native. Common; and Reference No. 3488, natural grassy pasture at seashore, 15 feet above sea-level, Veness, Orphir, Mainland, Orkney, 11th August 1926 (plants in full flower), H. H. Johnston. Native. Common. Dr. G. Claridge Druce pointed out this variety to me at Veness on 3rd August 1920.

HIERACIUM INULOIDES, *Tausch.*, *subsp. STRIATUM*, *Tausch.*, *var. b. PSEDAURATUM*, *Zahn* (*fide* J. Roffey, who saw all my herbarium specimens on 15th November 1926).—Sandstone

cliffs at seashore, 15 feet above sea-level, south side of Pegal Bay, Waas, Hoy, Orkney, 22nd August 1894 (plants in flower and fruit), and 7th August 1912 (plants in full flower), H. H. Johnston, native; and Reference No. 3484, grassy rocky sandstone cliffs at seashore, 15 feet above sea-level, Pegal Head, north side of Pegal Bay, Waas, Hoy, Orkney, 9th August 1926, H. H. Johnston, native, rare. Leaves dark green above, paler purplish-green beneath. Phyllaries blackish-green, clothed with blackish bristles. Corolla, stamens, and style with its two recoiled branches yellow. A new record for this variety for H. C. Watson's county No. 111 Orkney, discovered by me (Henry Halcro Johnston) on 22nd August 1894. The type of the subspecies *STRIATUM*, *Tausch.*, has not been recorded for Orkney. My specimens from the south side of Pegal Bay, collected on 22nd August 1894, were identified as "*HIERACIUM AURATUM*, *Fries.*," by Mr. F. J. Hanbury in 1894, and my specimens from the same station, collected on 7th August 1912, were identified under the same name by the Rev. E. F. Linton on 20th September 1912. See "*Annals Scot. Nat. Hist.*," No. 15, p. 178 (July 1895); Magnus Spence's "*Flora Orca-densis.*," p. 42 (1914); and CORRECTIONS, page 411 of this paper.

Hieracium aurantiacum, Linn. [*Hieracium aurantiacum*, Pugsley] (*fide* J. Roffey, who saw my herbarium specimen on 15th November 1926).—Reference No. 3330, top of a stone wall built with lime mortar, 90 feet above sea-level, near the garden of Holland House, Papa Westray, Orkney, 22nd June 1926, H. H. Johnston. Not native. A garden escape. Three plants, in full flower, only seen by me. Corolla orange-coloured. Anthers dull yellow. Style and its two recoiled branches dull greenish-yellow. In "*The London Catalogue of British Plants.*," eleventh edition, p. 30 (1925), *Hieracium aurantiacum*, *Pugsley*, is shown as a synonym of the subspecies No. 1266* *claropurpureum*, *Naegdi et Peter*; but the Rev. J. Roffey, in a letter to me, dated 21st December 1926, writes as follows, with reference to my specimen of Reference No. 3330, which he states is "the broad-leaved form of *H. aurantiacum*, L.":—"I queried *claropurpureum*, because I am now not quite certain of the identification. My friend Mr. Pugsley at any rate denies it, though, if the broad-leaved form does exist in the wild state (it is said to grow in low mountain-meadows in the

Tirol), I do not know what else it can be. Our ordinary narrow-leaved form is the *aurantiacum* of N. P., and following them, of all European botanists."

The aggregate species *TARAXACUM OFFICINALE*, *Wiggers*, is recorded for Orkney in Watson, "Top. Bot.," ed. ii, p. 236 (1883), but the following eight segregate species are not mentioned in that book.

GROUP V.—SPECTABILIA.

TARAXACUM BIPINNATIFIDUM (*Rostrup*), *Dahlstedt*.—Synonyms:—*TARAXACUM NÆVOSUM*, *Dahlstedt*, var. (?) *BIPINNATIFIDUM* (*Rostrup*), *Dahlstedt*, in C. H. Ostenfeld, "Additions and corrections to the list of the Phanerogamae and Pteridophyta of the Færøes"; *Arbejder fra den Botaniske Have, Kjöbenhavn* n. 37.—*TARAXACUM OBLIQUUM*, *Fries*, var. *BIPINNATIFIDUM*, *Rostrup*, "Færøernes Flora," p. 51 (1870).

Folia laete viridia, subtus pallidiora ±purpureo—maculata sat late oblongo—lanceolata, utrinque sparsim araneoso—pilosa, lobis in foliis exterioribus et intermediis deltoideis patentibus longis distantibus, interlobiis lateis ±longe dentatis sejunctis, ±crebre et longe laciniato—dentatis, lobo terminali brevi triangulari integro—dentato, lobis in foliis interioribus crebre laciniato—dentatis latioribus approximatis, lobo terminali longo et sat lato ovato—hastato lobatis exterioribus latis ±recurvis late et grosse dentatis, petiolis et nervo mediano pallidis.

Scapi quam folia longiores, apice ±colorati.

Involucrum exteriores anguste lineari—lanceolatae ±et saepe valde retroflexae, interiores superne dilutes virides et ±violascentes, interiores ±late lineares, omnes apice ±purpurascentes.

Calathium c. 4·5 cm. diametro.

Ligulae laete luteae, marginales extus stria virescenti purpurea notatae.

Antherae polliniferae.

Stylus et stigmata lutei.

Achenium fusco—stramineum, c. 4 mm. longum, c. 1 mm. latum, pyramide 0·5 mm. longa vel paullo extra anguste conica, superne breve tuberculatum.

This form seems to be identical with *TARAXACUM NÆVOSUM*, *Dahlstedt*, var. (?) *BIPINNATIFIDUM* (*Rostrup*), *Dahlstedt*, from the Færøes. It differs only from it through shorter not so deeply incised lobes, that are wanting in the Færøes form. It is undoubtedly related to *TARAXACUM NÆVOSUM*, *Dahlstedt*, but must, on account of the aberrant leaves, be regarded as a different species.

[I am indebted to Dr. Hugo Dahlstedt, Stockholm, Sweden, for the above description and remarks on this species, described by him, on 21st September 1926, from my six dried specimens of Reference No. 3319, all of which have been seen by him.—Henry Halcro Johnston.]

Locality.—Reference No. 3319 :—Grassy, shell-sandy ditch at roadside, 20 feet above sea-level, Public Road near the south end of the Loch of Saint Tredwall, Papa Westray, Orkney, 18th June 1926, H. H. Johnston. Native. Common. Plants in full flower and sparingly in fruit. Corolla yellow, striped greenish-purplish beneath in the outer florets. Fruit-receptacle flattish-convex. Achenes olive-brown. See “Botany of the Færøes,” part iii, p. 841 (1908).

TARAXACUM CHLOROLEUCOPHYLLUM, *Dahlstedt*, n. sp.

Folia sat obscure viridia, subtus pallidiora \pm lanceolato—oblonga, lobis plurimis valde hamatis et saepe valde retroversis longis, basi sat latis, acutis superioribus integris inferioribus \pm serrato—dentatis, approximatis vel intermediis brevibus dentatis sejunctis, lobo terminali ovato—sagittato margine convexo, integro vel inferne parce dentato acuminato, lobulis lateralibus vulgo valde recurvatis, petiolis et nervo mediano inferne \pm violascentibus.

Scapi plures quam folia longiores \pm colorati.

Squamae exteriores subpatentes recurvae \pm ovato-lanceolatae obtusiusculae, interiores \pm late lineares, omnes apice \pm coloratae.

Calathium parvum c. 4 cm. diametro.

Ligulae luteae, marginales extus stria obscure purpureo-violacea praeditae.

Antherae polline carentes.

Stylus et stigmata lutei.

Achenium vix 3 mm. longum, c. 1 mm. latum, pyramide brevi 0·5 mm. longo conico, apice acute spinulosum caeterum parce tuberculatum \pm fusco—stramineum. Rostrum 8 mm. longum.

This form belongs surely to the group *Spectabilia*, and seems to be very nearly allied to *Taraxacum serratifrons*, Dahlstedt. With regard to the leaves, this form has a very great resemblance to *Taraxacum chloroleucum*, Dahlstedt.

[I am indebted to Dr. Hugo Dahlstedt, Stockholm, Sweden, for the above description and remarks on this new species, described by him, on 15th September 1926, from my four dried specimens of Reference No. 3298, all of which have been seen by him.—Henry Halcro Johnston.]

Locality.—Reference No. 3298 :—Grassy banks at seashore, 10 feet above sea-level, How, Backaskail Bay, Cross, Sanday. Orkney, 14th June 1926, H. H. Johnston. Native. Common. Plants in full fruit and sparingly in flower, and growing close to plants of *TARAXACUM NÆVOSUM*, *Dahlstedt*, modification, and *TARAXACUM PERLACINIATUM*, *Dahlstedt*, n. sp., at the same station.

TARAXACUM LAETIFRONS, *Dahlstedt*.—The description of this species in "Trans. Bot. Soc. Edin.," vol. xxix, part i, p. 88 (1924), was made by Dr. Hugo Dahlstedt from my specimens of Reference No. 2265, from near Stromness Graveyard, Inner-town, Stromness, Mainland, Orkney, 13th June 1923; but, as the plants were only in flower and sparingly in unripe fruit, I collected more specimens (Reference No. 3013), in ripe fruit, at the same station, on 22nd June 1925, and sent fruits of them to Dr. Hugo Dahlstedt, to whom I am indebted for the following description of the achenes made by him at Stockholm, Sweden, on 21st October 1926 :—

Achenium stramineum, 3·5 mm. longum, 1 mm. latum obconicum, apice abrupte in pyramidem latam, conicam abiens, acute spinulosum, caeterum p. max. p. laeve vel leviter tuberculatum. Rostrum 7–7·5 mm. longum.

TARAXACUM SERRATILOBUM, *Dahlstedt*, n. sp.

Folia laete viridia, subtus pallidiora, parce araneoso-pilosa, angusta linearia—lineari-lanceolata, lobis sat approximatis—parum distantibus, interlobiis integris—dentatis

±deltoideis—hamatis et ±retroversis subintegris—crebre serrato-dentatis acutis, lobo terminali in foliis exterioribus et intermediis triangulari—sagittato integro—parce dentato brevi-suboblongato acuto in foliis interioribus majore vulgo dentato, petiolis leviter coloratis neovogue pallido.

Scapi plures vulgo quam folia breviores ±araneoso-pilosi, colorati.

Involucrum parvum ±atrovirens, basi ±ovata.

Squamae exteriores adpressae-laxe adpressae ±ovato-lanceolatae sat acuminatae anguste albomarginatae, interiores lineares ±obtusae, omnes apice ±purpurascences.

Calathium parvum 3·5–4 cm. diametro.

Ligulae luteae, marginales extus stria badio—violacea notatae.

Antherae polline carentes.

Stylus et stigmata lutei.

Achenium ignotum.

This form belongs undoubtedly to the group *Spectabilia*. It is nearly related to *TARAXACUM DEVIANS*, *Dahlstedt*, from Greenland, but differs from it by its narrower leaves with shorter, more recurved and more serrated lobes, its smaller heads and shorter corollas.

[I am indebted to Dr. Hugo Dahlstedt, Stockholm, Sweden, for the above description and remarks on this new species, described by him, on 12th September 1926, from my six dried specimens of Reference No. 3241, all of which have been seen by him.—Henry Halcro Johnston.]

Locality.—Reference No. 3241 :—Gravelled footpath in a graveyard, 15 feet above sea-level, Holm Churchyard, Holm, Mainland, Orkney, 3rd May 1926, H. H. Johnston. Native. Common. Plants in full flower. Corolla yellow, striped dull purplish-brown beneath in the outer florets.

TARAXACUM SERRATILOBUM, *Dahlstedt*, modification (*fide* Hugo Dahlstedt, who saw all my five dried specimens of Reference No. 3257 on 12th September 1926).—Reference No. 3257, grassy banks at seashore, 20 feet above sea-level, Valdegar, Holm, Mainland, Orkney, 5th May 1926, H. H. Johnston. Native. Rare. Plants in full flower and sparingly in fruit.

Corolla yellow, tinged purplish beneath in the outer florets. Achenes brown, spinulose-muricate at the apex.

GROUP VI.—VULGARIA.

TARAXACUM ALIENUM, *Dahlstedt*, in "Bot. Exch. Club Secretary's Report for 1926," vol. viii, part i, p. 30 (August 1927) (*fide* Hugo Dahlstedt, who saw all my twelve dried specimens of Reference No. 3244 at Stockholm, Sweden, in September 1926).—Reference No. 3244, natural grassy pasture at seashore, 15 feet above sea-level, west side of the mouth of Græmeshall Burn, Holm, Mainland, Orkney, 3rd May 1926, H. H. Johnston. Native. Common. Plants in full flower, and growing near Reference No. 3245, TARAXACUM PERLACINIOSUM, *Dahlstedt*, at the same station. Leaves dull green above, paler green beneath, not spotted, with a green or purplish-green midrib. Outer phyllaries recurved both in flower-bud and in the fully expanded flower; inner phyllaries adpressed, simple (not gibbous or appendaged) at the dull purple apex. Corolla yellow, striped dull purplish-brown beneath in the outer florets. Style and its two recurved branches yellow. A new record for this species for H. C. Watson's county No. 111 Orkney, discovered by me (Henry Halero Johnston) on 3rd May 1926.

TARAXACUM FULVICARPUM, *Dahlstedt*, n. sp.

Folia obscure viridia, immaculata, subtus pallidiora, longa, lineari-lanceolata—lineari-oblonga, lobis sat longis deltoideis basi \pm latis apicibus angustis acutis parum remotis, interlobiis \pm latis dentatis—angustioribus sat distantibus interlobiis longioribus subulato-dentatis, in inferiore margine integris vel parce dentatis, lobo terminali plerumque sat magno sat elongate hamatosagittato obtusiusculo-subacuto integro vel parce dentato, petiolis et nervo mediano pallidis vel pallide viridibus.

Scapi plures folia aequantes vel iis breviores, \pm colorati.

Involucrum mediocre, latiusculum, atrovirens, basi ovata.

Squamae exteriores \pm lineari-lanceolatae laxae adpressae vel \pm recurvatae, haud vel parum albomarginatae \pm corniculatae, interiores late lineari-lanceolatae, sub apice interdum leviter corniculatae-callosae.

Ligulae sat laetae, marginales extus stria obscure purpurea notatae.

Antherae polline carentes.

Stylus et stigmata sat obscure lutei.

Achenium magnum, 4·5 mm. longum, c. 1 mm. latum, pyramide 0·5 mm. longa conico—cylindrica, fulvo-brunescens, apice acute spinulosum, caeterum breve tuberculatum. Rostrum 11–15·5 mm. longum.

This form is nearly related to *Taraxacum fulvum*, Raunkier, with which it agrees in respect to the leaves and the somewhat appendaged phyllaries, but it differs from it in several respects. The outer phyllaries seem to be a little narrower and scarcely margined, and the achenes differ through their shorter rostra. They are also much longer and of a darker colour.

[I am indebted to Dr. Hugo Dahlstedt, Stockholm, Sweden, for the above description and remarks on this new species, described by him, on 16th September 1926, from my ten dried specimens of Reference No. 3344, all of which have been seen by him.—Henry Halcro Johnston.]

Locality.—Reference No. 3344 :—Grassy roadside, 90 feet above sea-level, Holland House, Papa Westray, Orkney, 24th June 1926, H. H. Johnston. Native. Common. Plants in full flower, unripe fruit, and sparingly in ripe fruit.

TARAXACUM PERLACINIATUM, *Dahlstedt*, n. sp.

Folia sat obscure viridia, subtus pallidiora, immaculata, elongate lanceolata-oblongo—lanceolata, multiloba, lobis approximatis deltoideis longis basi sat latis patentibus, in apice paullum resupinatis, obtusiusculis—acutis, subintegris—acute et longe dentatis, summis interdum recurvis, lobo terminali parvo-mediocri vel etiam sat magno, triangulari, subintegro-sparse dentato, obtusiusculo—acuto ± mucronato, lobo terminali in foliis interioribus majore et saepe latiore obtusiusculo—subacuto sat magno ± dentato, saepe sagittato, petiolis leviter violascentibus vel fere pallidis, nervo mediano pallido.

Scapi plures quam folia longiores pallidi superne ± colorati.

Involucrum sat magnum, atrovirescens, basi ± ovato-truncata.

Squamae exteriores anguste ovato-lanceolatae—lanceolatae
± recurvatae, haud marginatae.

Ligulae luteae, marginales extus stria sat obscure purpurascen-
cente notatae.

Antherae polliniferae.

Stylus et stigmata obscure lutei.

Achenium brunnescens, c. 3.5 mm. longum, vix 1 mm. latum,
pyramide 0.75–1 mm. longa subcylindrica, apice breve
spinulosum, caeterum fere laeve—parce tuberculatum.

This form belongs to the group *Vulgaria*. It is very allied to *Taraxacum lacinosum*, Dahlstedt, and *Taraxacum sublacinosum*, Dahlstedt et Lindberg fil., and is in respect to the leaves intermediate between both forms. It has, as *Taraxacum lacinosum*, Dahlstedt, recurved phyllaries. In *Taraxacum sublacinosum*, Dahlstedt et Lindberg fil., they are adpressed and broader.

[I am indebted to Dr. Hugo Dahlstedt, Stockholm, Sweden, for the above description and remarks on this new species, described by him, on 17th September 1926, from my seven dried specimens of Reference No. 3296, all of which have been seen by him.—Henry Halcro Johnston.]

Locality.—Reference No. 3296 :—Grassy banks at seashore, 10 feet above sea-level, How, Backaskail Bay, Cross, Sanday, Orkney, 14th June 1926, H. H. Johnston. Native. Common. Plants in flower and fruit, and growing close to *TARAXACUM CHLOROLEUCOPHYLLUM*, Dahlstedt, n. sp., and *TARAXACUM NÆVOSUM*, Dahlstedt, modification, at the same station.

TARAXACUM PERLACINIOSUM, Dahlstedt (*vide* Hugo Dahlstedt, who saw all my four dried specimens of Reference No. 3245, and one dried specimen of Reference No. 3361, at Stockholm, Sweden, on 17th and 21st September 1926, respectively). —Reference No. 3245, natural grassy pasture at seashore, 15 feet above sea-level, west side of the mouth of Græmeshall Burn, Holm, Mainland, Orkney, 3rd May 1926 (plants in full flower), H. H. Johnston, native, common, growing near Reference No. 3244, *TARAXACUM ALIENUM*, Dahlstedt, at the same station; and Reference No. 3361, grassy shell-sandy banks at seashore, 10 feet above sea-level, Bay of Moclett, Papa Westray, Orkney, 25th June 1926 (one plant in flower and one plant not in flower or fruit),

H. H. Johnston, native. Two plants only seen by me. The following notes were made by me from living plants of Reference No. 3245 on 3rd May 1926 :—Leaves dull green above, paler green beneath, not spotted, with a green or purplish-green midrib. Outer phyllaries recurved both in flower-bud and in the fully expanded flower ; inner phyllaries adpressed, simple (not gibbous or appendaged) at the dull purple apex. Corolla yellow, striped dull purplish-brown beneath in the outer florets. Style and its two recurved branches yellow. With reference to my specimen of Reference No. 3361, Dr. Hugo Dahlstedt, in a note, dated 21st September 1926, writes as follows :—“Seems to be a form of *TARAXACUM PERLACINIOSUM*, *Dahlstedt*.” This plant has the same characters as mentioned above for my Reference No. 3245, but in Reference No. 3361 the inner phyllaries are *simple or gibbous and appendaged* at the dull purplish apex in the *same capitulum*, the yellow corolla is striped *dull purplish* beneath in the outer florets, the anthers are brownish-yellow, and the style and its two recoiled branches are *brownish-yellow*. A new record for this species for H. C. Watson’s county No. 111 Orkney, discovered by me (Henry Halcro Johnston) on 3rd May 1926.

The aggregate species *CENTAUREA NIGRA*, *Linn.*, is recorded for Orkney in Watson, “*Top. Bot.*,” ed. ii, p. 247 (1883), but the following segregate species is not mentioned in that book :—

CENTAUREA OBSCURA, *Jordan* (*vide* C. E. Britton, who saw all my herbarium specimens on 16th November 1926).—(1) Side of a fence of Caithness flagstones, Swanbister, Orphir, Mainland, Orkney, 11th October 1880 (plants sparingly in flower), and 15th August 1881 (plants in full flower), H. H. Johnston, rare ; (2) sandy grassy pasture, Linksness, Hoy, Orkney, 31st August 1883 (plants in flower and flower-bud), H. H. Johnston, rare ; (3) plants growing among *AMMOPHILA ARENARIA*, *Link.* [= *PSAMMA ARENARIA*, *R. et S.*], in sandy links at the seashore, 20 feet above sea-level, Links of Melsetter, Waas, Hoy, Orkney, 11th August 1913 (plants in flower and flower-bud), H. H. Johnston, common at one place only ; (4) Reference No. 305, artificial grassy pasture, 30 feet above sea-level, near the Bu, Burray, Orkney, 27th July 1914 (plants beginning to flower), H. H. Johnston, common ; (5) natural grassy pasture between a road and a peat bog, 180

feet above sea-level, The Loons, Stromness, Mainland, Orkney, Reference No. 510, 15th August 1919 (plants in full flower), and Reference No. 563, 1st October 1919 (plants in full fruit), H. H. Johnston, rare ; (6) Reference No. 951, pasture at roadside, 30 feet above sea-level, Mill Dam Farm, North Ronaldsay, Orkney, 23rd August 1920 (plants in full flower), H. H. Johnston, common ; (7) Reference No. 1011, grassy border of a potato field, 40 feet above sea-level, Wideford, Saint Ola, Mainland, Orkney, 16th September 1920 (plants in full flower), H. H. Johnston, rare ; and (8) Reference No. 2070, pasture at seashore, 20 feet above sea-level, west side of Bay of Meil, Saint Ola, Mainland, Orkney, 26th August 1922 (plants in flower-bud and sparingly in flower), H. H. Johnston. Common. Native at all these eight stations in four different islands.

CENTAUREA OBSCURA, *Jordan*, form *PINNATIFIDA*, *C. E. Britton*, in "Bot. Exch. Club Secretary's Report for 1921," vol. vi, part iii, p. 409 (September 1922) (*fide* C. E. Britton, who saw all my herbarium specimens on 16th September 1926).—(1) Sandy grassy links, Lady, Sanday, Orkney, 7th July 1883 (plants in flower-bud), H. H. Johnston ; (2) grassy pasture, near Pierowall, Westray, Orkney, 13th July 1883 (plants in flower-bud), H. H. Johnston ; and (3) Reference No. 324, shell-sandy pasture near the seashore, 30 feet above sea-level, Crook, North Parish, South Ronaldsay, 29th July 1914 (plants in flower-bud), H. H. Johnston. Common. Native at all these three stations in three different islands.

EUPHRASIA BOREALIS, *Townsend*, var. *PUBESCENS*, *Townsend* (*fide* William Harrison Pearsall, who saw all my fourteen dried specimens of Reference No. 3300, and all my thirty-five dried specimens of Reference No. 3368, on 6th December 1926).—(1) Reference No. 3300, natural grassy shell-sandy pasture at seashore, 15 feet above sea-level, near Cross Churchyard, Cross, Sanday, Orkney, 14th June 1926, H. H. Johnston. Native. Common. Plants moderately in flower. Leaves 2-6 toothed. Corolla large, with a pale lilac upper lip and white lower lip, or both lips dark lilac, with dark purple lines on both lips, and a yellow spot on middle of middle lobe of lower lip. Mr. W. H. Pearsall, in a note on my specimens, dated 6th December 1926, writes as follows :—"The plants of this gathering exhibit considerable variation—as do most species of *EUPHRASIA*. The apparent lengthening of the corolla-tube

in a few of the flowers is not actual, but due to the flowers being ready to fall."

(2) Reference No. 3368, natural grassy pasture at seashore, 15 feet above sea-level, Holland, west side of Papa Westray, Orkney, 26th June 1926, H. H. Johnston. Native. Common. Plants in full flower. Leaves 2-6 toothed. Corolla large, with a light purple upper lip and white lower lip, with dark purple lines on both lips, and a yellow spot on middle of middle lobe of lower lip. Mr. W. H. Pearsall, in a note on my specimens, dated 6th December 1926, writes as follows :—" These plants possess very numerous and stout marginal setae, but the surfaces (apart from the slightly setose nerves) are practically glabrous. The upper bracts have ovate-lanceolate teeth ending in a transparent arista which is usually bi- and often trifurcate." A new record for this variety for H. C. Watson's county No. 111 Orkney, discovered by me (Henry Halcro Johnston) on 14th June 1926.

EUPHRASIA ATROVIOLOACEA, *G. C. Druce et D. Lumb*, in " Bot. Exch. Club Secretary's Report for 1923," vol. vii, part i, pp. 49-50 (November 1924) (*vide* Dennis Lumb, who saw all my herbarium specimens of Reference Nos. 3103 and 3104 on 14th July 1926, and William Harrison Pearsall, who saw six dried specimens of each of my Reference Nos. 3485 and 3486 on 7th January 1927).—Natural grassy shell-sandy pasture at seashore, 20 feet above sea-level, Links of Boardhouse, Birsay, Mainland, Orkney, (1) Reference Nos. 3103 and 3104, 23rd July 1925 (plants in full flower), and (2) Reference Nos. 3485 and 3486, 10th August 1926 (plants in full flower and sparingly in fruit), H. H. Johnston. Native. Common. Leaves 2-8 toothed. Corolla medium sized, rich dark purple in both lips, or with a pale purple upper lip and white lower lip, with dark purple lines on both lips, and a yellow spot on middle of middle lobe of lower lip.

I am indebted to Mr. W. H. Pearsall for the following remarks on my specimens of Reference Nos. 3485 and 3486, dated 7th January 1927 :—" Small, much branched plants, compact, of peculiar habit. The stem is usually very flexuose ; the branches widely spreading, variously arcuate, occasionally looped, often crossing the stem and frequently all secund. In many of the plants there is evidence of the stem or branches having been bitten off, and this accounts, in great measure,

for their congested habit. The spikes are normally condensed, and the upper bracts densely imbricated. The margins of the bracts are rough, with short, broad-based, incurved setulæ. The upper teeth of each bract are usually ovate, acute, non-aristate, and frequently 2, 3, or even 4-fid at the apex, but the lower teeth are often shortly and opaquely aristate. The upper bracts are, as a rule, very thin in texture and the lower bracts early caducous, leaving the glabrous base of the calyx visible. The glandular hairs—in both Nos.—are *extremely few in number but undeniably present*, and may be found, scattered singly, or occasionally in small clusters, on leaves, bracts, and calyx-teeth. They are most readily seen on the nerves of the under surfaces of the bracts—rather than on the margins. The capsules are relatively short, broad, and elliptical—scarcely narrowed upward, and usually tapering slightly more at the base than at the apex, which is commonly emarginate. The plants differ markedly from known British species. The flowers most resemble those of *Euphrasia Vigursii*, Davey, but are much more uniform in size. The habit and distribution, also, are quite distinct. The glandular hairs of EUPHRASIA ATROVIOLACEA, *G. C. Druce et D. Lumb*, are shorter and more uniform in size than those of any other British species. Those of normal EUPHRASIA BREVIPILA, *Burnat et Gremli*, are distinctly longer: those of *Euphrasia Vigursii*, Davey, are unequal in length—some relatively short and straight, others long and flexuous—but the shortest of them are many times the length of those of EUPHRASIA ATROVIOLACEA, *G. C. Druce et D. Lumb*. These plants are very similar to Reference Nos. 3103 and 3104 and are most acceptable.”

The pasture on the Links of Boardhouse is cropped short by cattle, sheep, and rabbits, which fact accounts for many of the stems or branches of EUPHRASIA ATROVIOLACEA, *G. C. Druce et D. Lumb*, having been bitten off, as mentioned above by Mr. W. H. Pearsall.

Confirms Dr. G. Claridge Druce's record of EUPHRASIA ATROVIOLACEA, *G. C. Druce et D. Lumb*, for H. C. Watson's county No. 111 Orkney (“Birsay, Orkney, *G. C. Druce* and *R. J. Burdon* 1920”), in “Bot. Exch. Club Secretary's Report for 1923,” vol. vii, part i, p. 50 (November 1924). See also “Bot. Exch. Club Distributor's Report for 1925,” vol. vii, part vi, pp. 1055–1056 (June 1926); and *ibid.* for 1926,

vol. viii, part ii, p. 270 (August 1927). This species was discovered by Dr. G. Claridge Druce, in my company, at the Links of Boardhouse, Birsay, on 4th August 1920.

Mentha rotundifolia, Huds.—Reference No. 3519, grassy banks at roadside, and Reference No. 3520, artificial grassy pasture in a garden, 200 feet above sea-level, Glenfield, Stromness, Mainland, Orkney, 18th September 1926 (plants in full flower), and 13th November 1926 (plants in withered flower, no fruit developed), H. H. Johnston. Not native. Rare. Fresh leaves with the aromatic odour of Mint. Corolla light purple.

CLASS II.—MONOCOTYLEDONS.

POTAMOGETON FILIFORMIS, *Pers.*, form CRINISIMILIS, *Hagström* (*fide* Arthur Bennett, December 1926).—Mud at bottom of shallow water in a loch, 7 feet above sea-level, Loch of Swartmill, Westray, Orkney, 6th September 1913, H. H. Johnston, native, common at the east end of the loch, plants in full fruit; and Reference No. 3212, probably this form (*fide* Arthur Bennett, who saw my two herbarium specimens on 21st October 1925), mud at bottom of clear fresh water, 10 feet deep, in a loch, near sea-level, north end of Loch of Harray, about $\frac{1}{4}$ mile south of the Holm of Kirkness, Sandwick, Mainland, Orkney, 30th September 1925, H. H. Johnston, native, common, plants not in flower or fruit. A new record for this form for H. C. Watson's county No. 111 Orkney, discovered by me (Henry Halcro Johnston) on 6th September 1913. See Mr. Arthur Bennett's remarks on my specimens from the Loch of Swartmill, Westray, in "Journ. Bot.," vol. lxiv, p. 331 (December 1926).

POTAMOGETON FILIFORMIS, *Pers.* × PECTINATUS, *Linn.* [=POTAMOGETON SUECICUS, *Richter*; and × POTAMOGETON SUECICUS, *Hagström*] (*fide* Arthur Bennett, December 1926).—Mud at bottom of water, 4 feet deep, in a loch, 51 feet above sea-level, Loch of Boardhouse, Birsay, Mainland, Orkney, 29th September 1913, H. H. Johnston. Native. Plants not in flower or fruit. A new record for this hybrid for H. C. Watson's county No. 111 Orkney, discovered by me (Henry Halcro Johnston) on 29th September 1913. See Mr. Arthur Bennett's remarks on my specimens from the Loch of Boardhouse in "Journ. Bot.," vol. lxiv, p. 331 (December 1926);

and CORRECTIONS, page 411 of this paper, where it is shown that the same specimens were identified as "POTAMOGETON PECTINATUS, *Linn.*," by Mr. Arthur Bennett, on 16th October 1913, and recorded by me under this name in "Trans. Bot. Soc. Edin.," vol. xxvi, p. 223 (1914).

ADDITIONS TO THE FLORA OF SHETLAND. By Colonel H. H. JOHNSTON, C.B., C.B.E., D.Sc., M.D., C.M., F.R.S.E., F.L.S.

(Read 16th June 1927.)

During a residence at Leagarth House, Fetlar, Shetland, as the guest of Sir William Watson Cheyne, Bt., K.C.M.G., C.B., from 19th to 31st May 1926, I collected specimens of nearly all the plants I found in flower or fruit in the island of Fetlar.

So far as I am aware, the following three species and varieties are new records for H. C. Watson's county No. 112 Shetland.

CALTHA PALUSTRIS, *Linn.*, *var. c. MINOR*, *DC.*—Reference No. 14, swamp, 230 feet above sea-level, between Skutes Water and Stackaberg, Fetlar, Shetland, 20th May 1926, Henry Halcro Johnston. Native. Common in the swamp. Plants in full flower. Stem decumbent, 1-flowered, or rarely 2-flowered. Sepals bright yellow. A new record for this variety for H. C. Watson's county No. 112 Shetland, discovered by me (Henry Halcro Johnston) on 20th May 1926.

CERASTIUM TETRANDRUM, *Curtis*, *var. d. EGLANDULOSUM*, *C. E. Salmon* (*fide* C. E. Salmon, who saw all my sixteen herbarium specimens of Reference No. 53 on 24th December 1926).—Reference No. 53, short natural grassy pasture at seashore, 10 feet above sea-level, Links of Tresta, Fetlar, Shetland, 24th May 1926, H. H. Johnston. Native. Common. Plants in full flower. Leaves, bracts, and calyx clothed with simple non-glandular hairs. Flowers tetramerous or pentamerous. Petals white, with a pale yellow base. A new record for this variety for H. C. Watson's county No. 112 Shetland, discovered by me (Henry Halcro Johnston) on 24th May 1926.

The aggregate species *TARAXACUM OFFICINALE*, *Wiggers*, is recorded for Shetland in Watson's "Topographical Botany," ed. ii, p. 236 (1883), but the following segregate species is not recorded in that book.

GROUP V.—SPECTABILIA.

TARAXACUM SHETLANDICUM, *Dahlstedt*, n. sp.

Folia obscure viridia supra purpureo—maculata utrinque praesertum i nervo dorsali parce—sparsim pilosa lata

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—latissima exteriora et intermedia obovato—oblonga—oblonga lobis brevibus latis—latissimis \pm hamatis \pm dentatis approximatis praedita, interiora latiora lobis brevioribus iis foliis intermediorum similibus vel breve lobato—dentata sat obtusa—breve acuta, lobo terminali lato ovato—sagittato integro vel \pm dentato a lobis lateralibus parum vel vix limitato, petiolis et nervo mediano \pm violascentibus.

Scapi plures folia aequantes vel parum superantes.

Involucrum atroviride basi ovato—truncata.

Squamae exteriores \pm recurvatae \pm ovato — lanceolatae in lamina superiore pallidiores et \pm violascentes, interiores late lineares, apice \pm obscure purpurascentes.

Calathium sat magnum 45–50 mm. diametro.

Ligulae luteae, marginales extus stria badio—purpurea notatae.

Antherae parce polliniferae.

Stylus cum stigmate \pm fusco—virescens.

Achenium obscure fusco—stramineum, c. 3·5 mm. longum, pyramide breve 0·5 mm. longo, superne \pm spinulosum inferne tuberculatum. Rostrum 8–8·5 mm. longum.

This form is very nearly allied to *T. NEVOSIFORME*, *Dahlstedt*, but differs from it especially through its ordinarily broader leaves and blunter lobes at the apex of the outer leaves. The lobes are also broader and more toothed. It seems to be a geographical form corresponding to *T. NEVOSIFORME*, *Dahlstedt*.

[I am indebted to Dr. Hugo Dahlstedt, Stockholm, Sweden, for the above description and remarks on this new species, described by him, on 11th September 1926, from my four dried specimens of Reference No. 20, all of which have been seen by him.]

Locality.—Reference No. 20 :—Gravelly roadside, 20 feet above sea-level, Leagarth House, Houbie, Fetlar, Shetland, 21st May 1926, H. H. Johnston. Native. Rare. Plants in flower and fruit.

ROLL

OF

THE BOTANICAL SOCIETY OF EDINBURGH.

Corrected to September 1927.

Patron:

HIS MOST GRACIOUS MAJESTY THE KING.

HONORARY FELLOWS.

BRITISH SUBJECTS (LIMITED TO SIX).

Date of Election.

- June 1923. DRUCE, G. CLARIDGE, M.A., LL.D., F.R.S., 9 Crick Road, Oxford.
 Nov. 1888. DYER, Sir WILLIAM TURNER THISELTON, M.A., LL.D., K.C.M.G.,
 C.I.E., F.R.S., *The Ferns, Witcombe, Gloucestershire.*
 Dec. 1907. FARMER, Sir JOHN BRETLAND, M.A., D.Sc., F.R.S., *Professor of
 Botany, Imperial College of Science and Technology, S. Ken-
 sington.*
 June 1923. PRAEGER, R. LLOYD, B.A., D.Sc., *National Library of Ireland,
 Kildare Street, Dublin.*
 June 1923. RENDLE, A. B., M.A., D.Sc., F.R.S., 28 Holmbush Road, Putney,
 London, S.W. 15.
 Feb. 1912. SCOTT, Dr. D. H., M.A., LL.D., Ph.D., F.R.S., *East Oakley House,
 Basingstoke, Hants.*

FOREIGN (LIMITED TO TWENTY-FIVE).

- June 1902. BRITTON, NATHANIEL LORD, *Director of the Botanic Garden, New York.*
 June 1923. CAMPBELL, Dr. DOUGLAS HOUGHTON, *Professor of Botany, Stanford
 University, California;—Corresponding Member, Dec. 1905.*
 June 1923. CHODAT, Professor Dr. ROBERT, *L'Université, Geneva.*
 June 1923. COULTER, JOHN MERLE, *Professor of Botany, University of Chicago;
 —Corresponding Member, Dec. 1905.*
 Feb. 1911. FLAHAULT, Dr. CHARLES, *Professor of Botany to the Faculty of Science,
 and Director of the Institute of the University, Montpellier.*
 June 1923. IKENO, Professor SEITSIRO, Ph.D., *Agricultural College, Imperial
 University, Tokio.*
 June 1923. LECOMTE, Professor HENRI, *Muséum d'Histoire Naturelle, Paris.*
 June 1923. LOTSY, Dr. J. P., *Spaarne 17, Haarlem.*
 June 1923. MACDOUGAL, Dr. D. T., *Director of Department of Botanical Research,
 Carnegie Institution, Tucson.*

Date of Election.

- June 1923. OSTENFELD, Dr. C. H., *Professor of Botany and Director of the Botanic Garden, Copenhagen.*
 June 1923. OSTERHOUT, W. J. V., Ph.D., *Rockefeller Institute, 66th Street and Avenue A., New York.*
 June 1923. THAXTER, PROFESSOR ROLAND, Ph.D., *7 Scott Street, Cambridge, Mass.*
 June 1902. TRELEASE, Dr. WILLIAM, *University of Illinois, Urbana, Illinois, U.S.A.*
 Mar. 1895. VRIES, Dr. H. DE, *Professor of Botany in the University, Amsterdam.*
 June 1923. WILSON, E. H., *Arnold Arboretum, Jamaica Plain, Mass.*

RESIDENT AND NON-RESIDENT FELLOWS.

No distinguishing mark is placed before the name of Resident Fellows who contribute annually and receive Publications.

* Indicates Resident Fellows who have compounded for Annual Contribution and receive Publications.

† Indicates Non-Resident Fellows who have compounded for Publications.

‡ Indicates Non-Resident Fellows who do not receive Publications.

Date of Election.

- Dec. 1915. Adam, Robert Moyes, *17 W. Brighton Crescent, Portobello.*
 Feb. 1905. †Aiken, Rev. J. J. Marshall Lang, B.D., *The Manse, Ayton, Berwickshire.*
 Jan. 1924. Aitken, Mrs. W., *2 Sycamore Terrace, Corstorphine.*
 Nov. 1924. *Alcock, Mrs. N. L., F.L.S., *14 Inverleith Row, Edinburgh.*
 Nov. 1884. †Alexander, J. A., *Waverley, Rossmore Avenue, Parkstone, Dorset.*
 Feb. 1925. Anderson, J. B., *30 Trinity Road, Edinburgh.*
 Jan. 1926. Anderson, Mark L., D.Sc., *4 Upper Mount Street, Dublin.*
 Nov. 1926. *Anthony, John, M.C., M.A., B.Sc., *7 Craigcrook Gardens, Edinburgh.*
 Dec. 1924. Armstrong, D., *The Drum, Gilmerton, Midlothian.*
 Dec. 1908. †Balfour, F. R. S., M.A., *39 Phillimore Gardens, Kensington, London, W.*
 Nov. 1924. Barker, Miss, *Edinburgh School of Gardening, Corstorphine.*
 Nov. 1926. Begg, A. V., W.S., *94 Inverleith Place, Edinburgh.*
 May 1891. *Berwick, Thomas, *56 North Street, St. Andrews.*
 Feb. 1919. †Blackburne, Cecil Ireland, *Valence, Westerham, Kent.*
 April 1926. Blackie, Joseph John, Ph.C., *104 Holyrood Road, Edinburgh.*
 May 1888. *Bonnar, William, *51 Braid Avenue, Edinburgh.*
 Jan. 1899. *Borthwick, A. W., O.B.E., D.Sc., *Professor of Forestry, The University, Aberdeen.*
 Dec. 1886. *Bower, F. O., M.A., D.Sc., F.R.S., F.L.S., *2 The Crescent, Ripon.*
 Mar. 1927. Boyd, Miss Lucy, *44 Bath Street, Portobello.*
 April 1913. †Brebner, James, *2 Scotswood Terrace, Dundee.*
 May 1924. †Brown, Miss Helen M., *Longformacus, Duns.*
 Dec. 1906. †Bryce, George, D.Sc., *Director of Rubber Research Institute, Kuala Lumpur, Fed. Malay States.*
 Nov. 1922. Buchanan, E. M., *76 Warrender Park Road, Edinburgh.*
 Nov. 1894. Buchan-Hepburn, Sir A., Bart., *Smeaton Hepburn, Prestonkirk.*
 Dec. 1921. †Burns, W., D.Sc., *Bombay Agric. Dept., Poona, Bombay, India.*
 Dec. 1924. †Burt, Miss C. C., B.Sc., *Lady Hardinge Medical College, Delhi, India.*
 Dec. 1915. Cadman, Miss Elsie, M.A., B.Sc., c/o *Ferguson, 9 Melville Terrace, Edinburgh.*
 Oct. 1926. *Callender, Wm. C., *Georgefield, 31 Inverleith Terrace, Edinburgh.*
 Nov. 1905. Campbell, Robt., M.A., D.Sc., *Geological Department, University of Edinburgh.*
 Apr. 1926. Cardross, The Rt. Hon. Lord, *Almondell House, Mid-Calder.*
 May 1861. †Coldstream, Wm., B.A., I.C.S. (retd.), *69 West Cromwell Road, London, S.W.*
 April 1913. †Cooper, R. E., *Govt. Botanic Garden, Maymyo, Burma.*
 Mar. 1900. *Cowan, Alexander, *Valleyfield, Penicuik.*
 Feb. 1923. †Cox, E. H. M., *32 Old Bond Street, London, W. 1.*
 Dec. 1915. *Craib, W. G., M.A., *Professor of Botany, Aberdeen.*
 Jan. 1924. *Currie, James, M.A., LL.D., *Larkfield, Wardie Road, Edinburgh.*
 Jan. 1922. *Dales, Mrs. H., M.A., B.Sc., *Allora, Kensington Gardens, Knock, Belfast.*

Date of Election.

- Dec. 1903. Davidson, J. Randolph, M.A., B.Sc., 49 *Meadway Court, Golders Green, London, N.W. 11.*
- Dec. 1911. †Davidson, John, *Assistant Professor of Botany, University of British Columbia, Vancouver, Canada.*
- Oct. 1926. Davy, V. E. M., B.Sc., *Plant Breeding Station, Corstorphine.*
- Dec. 1892. Day, T. Cuthbert, F.I.C., 36 *Hillside Crescent, Edinburgh.*
- Nov. 1925. De Pree, Mrs., *Beach Hill, Haddington.*
- April 1914. Dodd, A. Scott, B.Sc., 20 *Stafford Street, Edinburgh.*
- Nov. 1919. *Downie, Miss D. G., B.Sc., 1 *W. Stanhope Place, Edinburgh.*
- May 1921. Drummond, J. Montagu F., M.A., F.L.S., *Professor of Botany, University of Glasgow.*
- Dec. 1859. †Duckworth, Sir Dyce, Bart., M.D., LL.D., 28 *Grosvenor Place, London, S.W.*
- Feb. 1917. †Eley, Charles, *East Bergholt Place, Suffolk.*
- Nov. 1885. Elliot, G. F. Scott, M.A., B.Sc., F.L.S., *Drumwhill, Mossdale.*
- Jan. 1893. *Evans, Arthur H., Sc.D., 9 *Harvey Road, Cambridge.*
- Dec. 1905. *Evans, W. Edgar, B.Sc., 38 *Morningside Park, Edinburgh.*
- Mar. 1890. Ewart, J. Cossar, M.D., F.R.S.S. L. & E., *Craigyfield, Penicuik, Midlothian.*
- Oct. 1924. Ferguson, James Archibald, J.P., 78 *Inverleith Place, Edinburgh.*
- Feb. 1873. *France, Charles S., 13 *Cairnfield Place, Aberdeen.*
- Jan. 1906. *Fraser, James, 18 *Park Road, Leith.*
- Oct. 1920. *Galloway, R. Angus, M.C., B.Sc., 81 *Cluny Gardens, Edinburgh.*
- Dec. 1920. †Garriock, John, M.A., B.Sc., *Morgan Academy, Dundee.*
- May 1903. †Gilmore, Dr. Owen, L.R.C.P., L.R.C.S.E., 49 *Acre Lane, Brixton, London, S.W. 2.*
- Mar. 1927. Gorrie, Robert L., *The Ghyll, Cammo Road, Cramond Bridge.*
- Dec. 1907. Gourlay, Dr. W. Balfour, M.C., 7 *Millington Road, Cambridge.*
- Nov. 1921. *Graham, R. J. D., M.A., D.Sc., 45 *Stirling Road, Edinburgh.*
- Nov. 1923. Graham, Mrs., 45 *Stirling Road, Edinburgh.*
- Mar. 1923. Gray, John H., M.A., B.Sc., 28 *W. Relugas Road, Edinburgh.*
- Jan. 1926. Gregor, James W., Ph.D., *Craigs House, Corstorphine.*
- Mar. 1925. *Grieve, Miss Jean E., 11 *Lauder Road, Edinburgh.*
- Dec. 1895. *Grieve, Sommerville, 21 *Queen's Crescent, Edinburgh.*
- Feb. 1879. *Grieve, Symington, 11 *Lauder Road, Edinburgh.*
- Nov. 1914. †Harley, Andrew, *Blinkbonny, Kirkcaldy.*
- April 1910. Harvey, Miss Elsie, *Yewlands, Liberton.*
- Mar. 1913. †Hayward, Miss Ida M., F.L.S., 7 *Abbotsford Park, Galashiels.*
- May 1924. †Henderson, George, B.Sc., *Keith Grammar School, Keith, Banffshire.*
- April 1886. Hill, J. Rutherford, Ph.C., *Secretary, Pharmaceutical Society, 36 York Place, Edinburgh.*
- Feb. 1878. †Holmes, E. M., F.L.S., F.R.H.S., *Ruthven, Sevenoaks, Kent.*
- Oct. 1926. †Home, Miss Logan, *Edrom House, Edrom, Berwickshire.*
- June 1927. †Hornel, E. A., *Broughton House, Kirkcudbright.*
- Mar. 1920. Howison, Andrew, M.A., B.Sc., 18 *Beresford Avenue, Leith.*
- May 1925. Im Thurn, Sir Everard, K.C.M.G., K.B.E., *Cockenzie House, Prestonpans.*
- Dec. 1907. *Jeffrey, J. Frederick, *Laneside, Shipham, Winscombe, Somerset.*
- Oct. 1925. Johnston, Miss, *Aros, Colinton.*
- May 1877. *Johnston, Henry Halcro, C.B., C.B.E., D.Sc., M.D., F.L.S., *Colonel R.A.M.C., Mackay's Hotel, Stromness, Orkney.*
- Dec. 1912. *Johnstone, James Todd, M.A., B.Sc., *Royal Botanic Garden, Edinburgh.*
- Mar. 1925. Kean, Miss C. I., B.Sc., *Botanical Dept., University of St. Andrews.*
- Jan. 1913. *Kemp, Mrs. C. Norman, M.A., D.Sc., *Ivy Lodge, Laverockbank Road, Leith.*
- Nov. 1924. *King, Miss C. A., *Osborne Nursery, Corstorphine Road, Edinburgh.*
- Oct. 1921. King, Miss Isabella M., B.Sc., 4 *Cambridge Gardens, Edinburgh.*
- Jan. 1924. *Knox, Mrs. J., M.A., B.Sc., 14 *Merchiston Avenue, Edinburgh.*
- Nov. 1921. *Laing, Ernest V., M.A., B.Sc., 38 *Cedar Place, Aberdeen.*
- Dec. 1911. *Lamont, Miss Augusta, 73 *Falcon Road, Edinburgh.*
- Dec. 1917. Law, Mrs. John, 41 *Heriot Row, Edinburgh.*
- Feb. 1888. †Learmonth, Wm., *Fleetview, Gatehouse of Fleet.*
- Feb. 1878. †Lennox, David, M.D., F.C.S., *Ruddon Grange, Elie, Fife.*
- Dec. 1922. *Lewis, Herbert M., B.Sc., *Penucha, Caerwys, N. Wales.*
- Oct. 1925. †Low, Wm., *Balmakewan, Marykirk, Montrose.*
- Nov. 1922. †McCall, David, B.Sc., Ph.D., *Dundee Technical College, Bell Street, Dundee.*

Date of Election.

- Feb. 1925. Macdonald, James, B.Sc., *Imperial Forestry Institute, Oxford.*
 Jan. 1895. MacDougall, R. Stewart, M.A., D.Sc., 9 *Dryden Place, Edinburgh.*
 Jan. 1881. †Macfarlane, John M., Sc.D., F.R.S.E., *Emeritus-Professor of Botany, 4320 Osage Avenue, Philadelphia.*
 Feb. 1886. M'Glashan, D., *Kingscroft, Cramond Bridge.*
 Dec. 1925. *M'Intosh, A. E. S., B.Sc., 39 *Bruntsfield Place, Edinburgh.*
 June 1880. *M'Intosh, W. C., M.D., LL.D., F.R.S.S. L. & E., F.L.S., 2 *Abbotsford Crescent, St. Andrews.*
 Dec. 1925. Mackie, Miss A. W., 11 *Bellevue Terrace, Edinburgh.*
 June 1897. †Macvicar, Symers M., *Invermoidart, Acharacle, Argyllshire.*
 Feb. 1914. Macwatt, John, M.B., C.M., *Morelands, Duns.*
 Dec. 1896. †Mahalanobis, Professor S. C., B.Sc., F.R.S.E., *Presidency College, Calcutta.*
 Oct. 1914. *Martin, Isa, M.A., 69 *Arden Street, Edinburgh.*
 Dec. 1923. †Massey, Miss K., B.Sc., *Glenanore, Disley, Cheshire.*
 Jan. 1902. Massie, William Hall, *Redbraes House, Broughton Road, Edinburgh.*
 Mar. 1913. *Matthews, James R., M.A., *Royal Botanic Garden, Edinburgh,—HONORARY SECRETARY.*
 May 1926. †Maxwell, Miss Iris, B.Sc., *Mount Charles, Giddy Hall, Jamaica.*
 Dec. 1916. †Maxwell, Sir John Stirling, Bart., *Pollok, Pollokshaws, Glasgow.*
 Oct. 1925. Mercer, Miss Edith, 10 *Ventnor Terrace, Edinburgh.*
 Feb. 1902. *Millar, R. C., C.A., 6 *Regent Terrace, Edinburgh,—AUDITOR.*
 April 1919. †Mills, A. E., 8 *George Street, Bath.*
 July 1878. †Muirhead, George, LL.D., F.R.S.E., *Gordon Estates Office, Fochabers.*
 Oct. 1918. †Murray, J. M., B.Sc., 25 *Drumsheugh Gardens, Edinburgh.*
 Dec. 1923. *Nelson, Alex., B.Sc., Ph.D., *Supt. of Research, Dept. of Agriculture, Hobart, Tasmania.*
 April 1916. †Nicholson, C., Esq., F.E.S., 35 *The Avenue, Hale End, Chingford, Essex.*
 Feb. 1894. Novar, The Rt. Hon. Viscount, G.C.M.G., of *Raith and Novar, Kirkcaldy.*
 Dec. 1907. *Orr, Matt. Y., *Royal Botanic Garden, Edinburgh.*
 Oct. 1914. †Patton, Donald, Ph.D., M.A., B.Sc., 9 *Thornwood Gardens, Broomhill, Glasgow.*
 April 1883. *Paul, Very Rev. David, M.A., LL.D., D.D., *Carriale, Fountainhall Road, Edinburgh,—FOREIGN SECRETARY.*
 Nov. 1919. Pealling, Robert J., M.A., B.Sc., *The Royal Academy, Inverness.*
 Dec. 1917. *Pike, J. Lyford, B.Sc., *Rosetta, Liberton.*
 Jan. 1915. *Pinkerton, A. A., *Adele Cottage, Loanhead.*
 June 1891. †Prain, Sir David, M.D., C.I.E., F.R.S.S. L. & E., F.L.S., *The Well Farm, Warlingham, Surrey.*
 April 1877. †Riddell, Wm. R., B.A., B.Sc. (Hon. Mr. Justice), *Osgoode Hall, Toronto, Canada.*
 Feb. 1926. Robb, William, N.D.A., *Craigs House, Corstorphine.*
 April 1927. Robertson, J. R., 30 *Mayfield Terrace, Edinburgh.*
 Dec. 1890. Robertson, Robert A., M.A., B.Sc., *Lecturer on Botany, Bute Medical School, St. Andrews.*
 Jan. 1923. †Rollo, Hon. Bernard F., *Keltie Castle, Dunning.*
 Feb. 1905. *Ross, A. J., M.A., B.Sc., *Schoolhouse, Gretna.*
 Mar. 1925. †Rothschild, Lionel N. de, *Exbury, near Southampton.*
 Mar. 1902. Sampson, Hugh C., B.Sc., *The Riding, Riding Mill on Tyne, Northumberland.*
 Feb. 1925. Sansome, F. W., B.Sc., Ph.D., 2 *Cluny Place, Edinburgh.*
 Dec. 1887. †Scott, J. S., L.S.A., 69 *Clowes Street, West Gorton, Manchester.*
 Dec. 1922. Seaton, Ian W., B.Sc., *Plant Breeding Station, Stormount, Stranstown, Belfast.*
 June 1922. †Simpson, J. R., *The Limes, Selkirk.*
 Dec. 1922. Smith, Miss Edith Philip, B.A., Ph.D., F.L.S., 46 *Murrayfield Drive, Edinburgh.*
 Nov. 1926. †Smith, H. Guthrie, *Tutira, Napier, New Zealand.*
 Feb. 1891. *Smith, J. Pentland, M.A., B.Sc., *Carnbie, Bridge of Weir, Renfrewshire.*
 Nov. 1914. *Smith, James L. S., M.A., B.Sc., 17 *Cargill Terrace, Edinburgh.*
 Dec. 1917. †Smith, J. T., 68 *Tennant Street, Glasgow.*
 Dec. 1909. Smith, Wm. G., B.Sc., Ph.D., 9 *Braidburn Crescent, Edinburgh.*
 Jan. 1902. *Smith, Professor W. Wright, M.A., *King's Botanist, Regius Keeper, Royal Botanic Garden, Edinburgh.*
 Jan. 1890. *Somerville, Sir William, K.B.E., D.Sc., D.Ec., *Rye House, Foxcombe Hill, near Oxford.*

Date of Election.

- Jan. 1925. Sommerville, Charles W., *Gracemount, Liberton, Edinburgh.*
 Nov. 1923. †Stern, Frederick, *Highdown, Goring-on-Sea.*
 Dec. 1923. Steven, H. M., B.Sc., Ph.D., *Imperial Forestry Institute, Oxford.*
 Oct. 1923. †Stevenson, J. B., *Tower Court, Ascot.*
 Oct. 1914. †Stewart, Edward J. A., M.A., B.Sc., *8 Manor Road, Jordanhill, Glasgow.*
 Oct. 1918. †Stewart, Capt. William, *Shambellie, Kirkcudbright.*
 April 1921. Sutherland, John, C.B.E., LL.D., *11 Inverleith Row, Edinburgh.*
 Feb. 1902. Tagg, Harry F., F.L.S., *Royal Botanic Garden, Edinburgh.*
 Jan. 1913. †Tagg, M. H., *53 Clayton Avenue, Wembley, Middlesex.*
 Oct. 1926. *Taylor, George, B.Sc., *2 Viewforth Gardens, Edinburgh.*
 Dec. 1922. †Taylor, George Crosbie, B.Sc., F.L.S., *20 Tavistock Street, Covent Garden, London, W.C. 2.*
 Dec. 1923. †Taylor, James, M.A., B.Sc., *The Academy, Kirkcudbright.*
 May 1923. †Taylor, R. A., M.A., B.Sc., *Culloden Estates, Neboda, Ceylon.*
 Dec. 1887. Terras, J. A., B.Sc., *40 Findhorn Place, Edinburgh.*
 April 1921. †Thompson, J. MacLean, M.A., D.Sc., F.L.S., *Professor, Department of Botany, University, Liverpool.*
 Jan. 1909. Thompson, Miss Jean G., B.Sc., *19 Pentland Terrace, Edinburgh.*
 Nov. 1922. *Urquhart, Mrs. Douie, *42 India Street, Edinburgh.*
 Nov. 1921. Walker, Miss Marion, M.A., *12 Chancelot Terrace, Edinburgh.*
 Oct. 1918. †Watson, Harry, *Beaufort Forest School, Kiltarity, Bearly.*
 Mar. 1925. *Watt, James, LL.D., W.S., *28 Charlotte Square, Edinburgh.*
 Nov. 1921. *Watt, Miss Janet, *6 W. Catherine Place, Edinburgh.*
 Dec. 1922. Wilson, Miss Dorothy G., B.Sc., *Secondary School for Girls, Stockton-on-Tees.*
 Feb. 1912. *Wilson, Malcolm, D.Sc., *Brentknoll, Kinnear Road, Edinburgh.*
 Mar. 1909. *Wilson, Thos., Ph.C., *110 High Street, Burntisland.*
 May 1873. †Wright, Professor R. Ramsay, M.A., B.Sc., *Red Gables, Headington Hill, Oxford.*
 Jan. 1903. Young, William, *Fairview, Kirkcaldy.*
 Jan. 1923. *Younger, Harry Geo., *Benmore, Kilmun, Argyllshire.*

ORDINARY MEMBERS.

- Nov. 1923. Cannon, Mrs. H. G., *The University, Sheffield.*
 Nov. 1926. Clark, Miss J. S., *4 Bruntfield Terrace, Edinburgh.*
 Dec. 1923. Cunningham, Miss Lily M., B.Sc., *133 Whitaker Road, Derby.*
 April 1925. Dawson, W., *14 Royston Terrace, Edinburgh.*
 Oct. 1924. Dickson, Miss A. M., *The Shieling, Corstorphine.*
 Nov. 1926. Drysdale, Miss D., *Royal Botanic Garden, Edinburgh.*
 May 1921. Jardine, Miss Gertrude, *26 Murrayfield Road, Edinburgh.*
 May 1925. Low, Miss Jane, *106 Ferry Road, Leith.*
 April 1925. M'Ilvenna, Wm. R., *8 Inverleith Terrace, Edinburgh.*
 Nov. 1926. MacIachlan, Miss C. M., *13 South Gray Street, Edinburgh.*
 Mar. 1926. Morrison, R., *5 Bright Terrace, Edinburgh.*
 Nov. 1926. Redman, Miss A. W. H., *30 Lomond Road, Leith.*
 April 1925. Robertson, Frederick W., *23 Inverleith Place, Edinburgh.*
 April 1925. Robertson, Mrs. Marjory F., *23 Inverleith Place, Edinburgh.*
 Nov. 1922. Seaton, Mrs., *Plant Breeding Station, Belfast.*
 Nov. 1926. Smith, Miss M. H., *Inverleith House, Edinburgh.*
 April 1925. Smith, Thomas Arthur, *39 Restalrig Road, Leith.*
 Nov. 1926. Steven, G. A., *c/o Pringle, 19 Montpelier Park, Edinburgh.*
 Dec. 1923. Wallace, G. B., B.Sc., *9 Graham Street, Edinburgh.*
 Feb. 1925. Watts, Annie M., B.Sc., *53 George Square, Edinburgh.*
 Nov. 1922. Wilson, Miss M. J. F., B.Sc., *21 Inverleith Place, Edinburgh.*

ASSOCIATES.

- Mar. 1886. Bennett, A., A.L.S., *5 Thanet Place, High Street, Croydon.*
 Jan. 1906. Harrow, R. L., *Royal Botanic Garden, Edinburgh.*
 Feb. 1919. Johnson, Norman M., B.Sc., *Ardgarth, Victoria Terrace, Dunfermline.*
 Dec. 1883. Richardson, Adam D., *19 Joppa Road, Portobello, Midlothian.*
 Jan. 1906. Stewart, L. B., *Royal Botanic Garden, Edinburgh.*

LADY MEMBERS.

Date of Election.

- June 1893. Aitken, Mrs. A. P., 15 *Victoria Mansions, West Hampstead, London, N.W.*
 April 1893. Balfour, Lady Bayley, *Penfold's Corner, Haslemere, Surrey.*
 Dec. 1926. Callender, Mrs. C. A., 31 *Inverleith Terrace, Edinburgh.*
 Feb. 1910. Galletly, Mrs. Sarah H., 32 *Mansionhouse Road, Edinburgh.*
 April 1902. Grieve, Mrs. Symington, 11 *Lauder Road, Edinburgh.*
 Nov. 1926. Smith, Mrs., *Inverleith House, Edinburgh.*

CORRESPONDING MEMBERS.

- Dec. 1905. Beijerinck, M. W., *Professor of Bacteriology, Delft.*
 Dec. 1905. Cockayne, L., Ph.D., F.R.S., F.L.S., *Ngaio, Wellington, New Zealand.*
 June 1902. Constantin, Dr. J., *Professeur au Muséum d'Histoire Naturelle, Paris.*
 Mar. 1895. Elfving, Dr. Fredrik, *Professor of Botany in the University, and Director of the Botanic Garden, Helsingfors.*
 Dec. 1905. Gravis, Auguste, *Professor at the University, and Director of the Botanic Garden, Liège.*
 Mar. 1895. Guignard, Léon, *Membre de Institut, Rue du Val-de-Grâce 6, Paris.*
 June 1902. Henriques, Julio A., *Professor of Botany in the University, and Director of the Botanic Garden, Coimbra.*
 May 1891. Henry, Augustine, M.A., F.L.S., *Professor of Forestry, Royal College of Science, Dublin.*
 Dec. 1905. Mattiolo, Dr. Oreste, *Professor of Botany in the University, and Director of the Botanic Garden, Torino, Piedmont.*
 Dec. 1905. Miyabe, Dr. Kingo, *Professor of Botany, Hokkaido Imperial University, and Director of the Botanic Garden, Sapporo, Hokkaido, Japan.*
 June 1902. Miyoshi, Manabu, *Professor of Botany in the Imperial University, Tokio.*
 June 1902. Raunkiaer, Professor Christen, *Botanic Museum, Copenhagen.*
 Dec. 1905. Rodway, Leonard, *Government Botanist of Tasmania, Hobart.*
 Dec. 1905. Schröter, Dr. Carl, *Professor of Botany, and Director of the Botanical Museum, Zürich.*

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- Belfast*, Natural History and Philosophical Society.
Berwick, Berwickshire Naturalists' Club.
Bristol, Bristol Naturalists' Society.
Cambridge, Philosophical Society.
Cardiff, Naturalists' Society.
Dublin, Royal Dublin Society.
Dumfries, Dumfriesshire and Galloway Natural History Society.
East Malling, East Malling Research Station.
Edinburgh, Edinburgh Geological Society.
 Royal Scottish Arboricultural Society.
 Royal Scottish Geographical Society.
 Royal Scottish Society of Arts.
 Royal Society of Edinburgh.
 University of Edinburgh.
Glasgow, Natural History Society.
 Royal Philosophical Society.
 University of Glasgow.
Hull, Yorkshire Naturalists' Union.
Leeds, University of Leeds.
Liverpool, Hartley Botanical Laboratories.
London, Editor of *Gardeners' Chronicle*.
 Editor of *Nature*.
 Linnean Society.
 Ministry of Agriculture.
 Quekett Microscopical Club.
 Royal Botanic Gardens, Kew.
 Royal Horticultural Society.
 Royal Microscopical Society.
 Royal Society.
 Science Library, South Kensington.
Manchester, Manchester Literary and Philosophical Society.
Millport, Scottish Marine Biological Association.
Newcastle-
upon-Tyne, Natural History Society of Northumberland, Durham,
 and Newcastle-on-Tyne.
 University of Durham Philosophical Society.
Norwich, Norfolk and Norwich Naturalists' Society.
Perth, Perthshire Society of Natural Science.
Plymouth, Plymouth Institution.
Stratford, Essex Field Club.
Watford, Hertfordshire Natural History Society and Field Club.

AUSTRIA.

- Graz*, Naturwiss. Verein für Steiermark.
Vienna, Zoologisch-Botanische Gesellschaft.

BELGIUM.

- Brussels*, Académie Royale de Belgique.
 Institut Botanique Léo Errera.
 Société Royale de Botanique de Belgique.

BULGARIA.

- Sofia*, Société Botanique de Bulgarie.

CZECHOSLOVAKIA.

- Prague*, Czechoslovakian Botanical Society.
 Plant Physiological Laboratory of Charles University.

DENMARK.

- Copenhagen*, Botanisk Haves Bibliothek.
 Dansk Botanisk Forening.
Disko, Greenland, . . Den Danske Arktiske Station.

FINLAND.

- Helsingfors*, Societas pro Fauna et Flora Fennica.
 Societas Zoolog-Botanica Fennica Vanamo.
 Society of Forestry in Finland.

FRANCE.

- Amiens*, Société Linnéenne du Nord de la France.
Brest, Société Botanique et Entomologique de Gers.
Cherbourg, Société Nationale des Sciences Naturelles.
Lyon, Société Linnéenne de Lyon (Section Botanique).
Marseille, Faculté des Sciences de Marseille.
Paris, Société Botanique de France.
Toulouse, Société d'Histoire naturelle.

GERMANY.

- Berlin*, Botanischer Verein der Provinz Brandenburg.
Bonn, Naturhist. Verein d. Preussischen Rheinlande, etc.
Breslau, Schlesische Gesellschaft f. Vaterländ. Kultur.
Frankfurt-a-M., Senckenbergische Bibliothek.
Giessen, Oberhessische Gesellschaft für Natur- und Heil-Kunde.

HOLLAND.

- Amsterdam*, Botanical Society of Holland.
 Koloniaal Instituut.
 Koninklijke Akademie van Wetenschappen.
Haarlem, Musée Teyler.
Leiden, Rijks Herbarium.
Wageningen, State Agricultural Library.

HUNGARY.

- Budapest*, Hungarian Association of Natural Sciences.

ITALY.

- Florence*, Societa Botanica Italiana.
Rome, International Institute of Agriculture.
 Regio Istituto Botanico.
Catania, Sicily, . . Orto Botanico d'Universita.

LUXEMBOURG.

- Luxembourg*, Société Botanique du Grand-duché de Luxembourg.

NORWAY.

- Oslo*, Botanic Garden.
Tromsø, Tromsø Museum.

POLAND.

- Krakow*, Laboratorium Botanicum Janczewskianum.
 Polish Academy of Science.
Warsaw, Société Botanique de Pologne.

PORTUGAL.

- Coimbra*, Instituto Botanico, Universidade.
Lisbon, Academia das Sciencias.

RUSSIA.

- Kiew*, Société des Naturalistes de Kiew.
Leningrad, Academy of Sciences.
 Botanic Garden.
Moscow, Société des Naturalistes de Moscou.
Tashkent, First Central Asiatic University.

SWEDEN.

- Gothenburg*, Goteborgs Botaniska Tradgard.
Lund, Universitas Lundensis.
Stockholm, Kungl. Svenska Vetenskaps Akademien.
 Svenska Botaniska Föreningen.
Upsala, Kungl. Vetenskaps Societeten.

SWITZERLAND.

- Berne*, Naturforschende Gesellschaft.
Geneva, Conservatoire et Jardin Botaniques.
 Institut Botanique, Herbar Boissier.
Zurich, Naturforschende Gesellschaft.
 Schweizerische botanische Gesellschaft.

AFRICA.

- Cape Town*, South African Museum.

ASIA.

- Calcutta*, Royal Botanic Garden.
Pusa, Agricultural Research Station.
Peradeniya, Royal Botanic Gardens.
Singapore, Botanic Gardens.
Manila, Bureau of Science.
Buitenzorg, Departement van Landbouw, Nijverheid en Handel.
Formosa, Department of Forestry.
Kurashiki, Ohara Institute for Agricultural Research.
Sapporo, Sapporo Natural History Society.
Sendai, Biological Institute, Tohoku Imperial University.
Tokio, College of Agriculture, Imperial University.

AUSTRALASIA.

- Brisbane*, Department of Agriculture.
 Royal Society of Queensland.
Hobart, Royal Society of Tasmania.

- Melbourne*, . . . Botanical Department, University of Melbourne.
National Herbarium.
Royal Society of Victoria.
Sydney, . . . Fisher Library, Sydney University.
Royal Society of New South Wales.
Wellington, . . . New Zealand Institute.

CANADA.

- Halifax*, . . . Nova Scotian Institute of Natural Science.
Montreal, . . . M'Gill University.
Ottawa, . . . Canadian Forestry Association.
Central Experiment Farms.
Department of Agriculture.
Department of the Interior, Forestry Branch.
Geological Survey of Canada.
Toronto, . . . Royal Canadian Institute.

SOUTH AMERICA.

- Bogota, Rep. of* } Ministry of Public Works.
Colombia, }
Buenos Aires, . . Museo Nacional de Historia Natural, Seccion Botanica.
La Plata, . . . Museo de La Plata.
Monte Video, . . Museo Nacional de Monte Video.
Rio de Janeiro, . Botanic Garden.
Museu Nacional.
San Paulo, . . . Museu Paulista (Secção de Botanica).

UNITED STATES.

- Ann Arbor, Mich.*, University of Michigan.
Berkeley, Cal., . University of California.
Boston, Mass., . Massachusetts Horticultural Society.
Society of Natural History.
Brooklyn, N. Y., . Brooklyn Botanic Garden.
Cambridge, Mass., Gray Herbarium, Harvard University.
Cincinnati, O., . Lloyd Botanical Library.
Society of Natural History.
Colorado }
Springs, Col., } Colorado College.
Columbia, Mo., . Library of University of Missouri.
Columbus, O., . Ohio State University.
Geneva, N. Y., . . Agricultural Experiment Station.
Indianapolis, Ind., Indiana Academy of Sciences.
Ithaca, N. Y., . . New York State College of Agriculture.
Jamaica Plain, }
Mass., } Arnold Arboretum.
Lawrence, Kan., . Academy of Science.
Madison, Wis., . Wisconsin Academy of Sciences.
Manhattan, Kan., State Agricultural College.
Milwaukee, Wis., . Public Museum.
Minneapolis, }
Minn., } Botanical Department, University of Minnesota.
New Haven, Conn., Academy of Arts and Sciences.
New York, N. Y., Academy of Sciences.
Torrey Botanical Club.
Philadelphia, Pa. . Academy of Natural Sciences.
American Philosophical Society.
University of Pennsylvania.

- Rochester, N. Y.* . . Rochester Academy of Sciences.
St. Louis, Mo. . . . Missouri Botanical Garden.
San Francisco, }
Cal., } California Academy of Sciences.
Urbana, Ill., . . . University of Illinois.
Washington, D.C. . National Academy of Sciences.
 Smithsonian Institution.
 United States Department of Agriculture; Forest Ser-
 vice; National Museum; Office of Experiment
 Stations.

WEST INDIES.

- Jamaica,* . . . Department of Agriculture.
Trinidad, . . . Royal Botanic Garden.

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 Alcock, Mrs., xii.
 Anderson, J., xiv.
 Anderson, Mark L., xxi.
 Anthony, John, xxviii.
 Armstrong, D., xii.
 Barker, Miss, xii.
 Begg, A. V., xxviii.
 Blackie, Joseph John, xxiii.
 Boyd, Miss Lucy, xxx.
 Brough, Robert, v.
 Brown, Miss Helen M., vi.
 Burt, Miss C. C., xii.
 Callender, W. C., xxvii.
 Cardross, Rt. Hon. Lord, xxiii.
 Currie, James, v.
 Davy, V. E. M., xxvii.
 De Free, Mrs., xx.
 Ferguson, James Archibald, xi.
 Gorrie, Robert L., xxx.
 Gregor, J. W., xxi.
 Grieve, Miss Jean E., xiv.
 Hardy, F. A., iii.
 Henderson, Miss E. M., v.
 Henderson, George, vi.
 Home, Miss Logan, xxvii.
 Im Thurn, Sir Everard, xvi.
 Inglis, Mrs. D. M., xii.
 Johnston, Miss, xix.
 Kean, Miss C. I., xiv.
 King, Miss C. A., xii.
 Low, Wm., xix.
 Macdonald, James, xiv.
 M'Intosh, A. E. S., xxi.
 Mackie, Miss A. W., xxi.
 Massey, K., iv.
 Maxwell, Miss Iris, xxiv.
 Mercer, Miss Edith, xix.
 Nelson, Alex., iv.
 Noble, Miss E. I., xxi.
 Reid, Miss Oona, iv.
 Rifat, Ahmed, xiv.
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- New Fellows—*continued*.
 Sansome, F. W., xiv.
 Smith, H. Guthrie, xxviii.
 Sommerville, Charles W., xiii.
 Stern, Frederick, iv.
 Steven, H. M., iv.
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PROCEEDINGS
OF THE
BOTANICAL SOCIETY OF EDINBURGH.

SESSION LXXXVIII

OCTOBER 18, 1923.

Professor W. WRIGHT SMITH, M.A., F.L.S., F.R.S.E., President,
in the Chair.

The following Office-Bearers were elected for Session
1923-1924:—

PRESIDENT.

Professor W. WRIGHT SMITH, M.A., F.L.S., F.R.S.E.

VICE-PRESIDENTS.

A. W. BORTHWICK, O.B.E., D.Sc.	SYMINGTON GRIEVE, Esq.
JAMES FRASER, Esq.	J. RUTHERFORD HILL, Esq.

COUNCILLORS.

Miss ELSIE CADMAN, M.A., B.Sc.	Mrs C. NORMAN KEMP, M.A., D.Sc.
T. CUTHBERT DAY, Esq.	Miss AUGUSTA LAMONT, B.Sc.
J. MONTAGU F. DRUMMOND, B.A., F.L.S.	W. G. SMITH, B.Sc., Ph.D.
R. GLODE GUYER, Esq.	MALCOLM WILSON, D.Sc., F.L.S., F.R.S.E.
ANDREW HOWISON, M.A., B.Sc.	WILLIAM YOUNG, Esq.

Honorary Secretary—J. R. MATTHEWS, M.A., F.L.S., F.R.S.E.

Foreign Secretary—Very Rev. D. PAUL, M.A., D.D., LL.D.

Treasurer—ANDREW MASON, Esq., c/o RICHARD BROWN & Co., C.A.

Assistant-Secretary—J. T. JOHNSTONE, M.A., B.Sc.

Artist—Professor FRANCIS M. CAIRD, M.B., C.M., F.R.C.S.E.

Auditor—ROBERT C. MILLAR, C.A.

The TREASURER, Mr. ANDREW MASON, submitted the following Statement of Accounts for Session 1922-1923:—

INCOME.

Annual Subscriptions for 1922-1923	£41 0 0
Do. Arrears	6 0 0
Transfer from Life Members' Fund	16 14 11
Transactions sold	7 0 0
Interest on Funds Invested and in Bank	8 4 10
Subscriptions to Publications Fund	35 3 0
	<hr/>
	£114 2 9

EXPENDITURE.

Printing <i>Transactions</i> for Session 1921-1922	£61 0 9
Printing Notices for Meetings, etc.	21 14 8
Rooms for Meetings and Tea	11 10 7
Stationery, Postages, Carriages, etc.	4 11 9
Fire Insurance on Books, etc.	0 5 0
Honorarium to Treasurer	3 3 0
	<hr/>
	£102 5 9
Excess of Income over Expenditure	<hr/>
	£11 17 0

STATE OF FUNDS.

Life Members' Fund.

Balance of Fund at close of Session 1921-1922	£177 12 7
Add—Life compositions received	44 2 0
	<hr/>
	£221 14 7
Deduct—Transferred to Income	16 14 11
	<hr/>
Balance as at close of Session	£204 19 8

Ordinary Fund.

Balance of Fund at close of Session 1921-1922	£53 7 7
Add—Increase during Session 1922-1923	11 17 0
	<hr/>
Balance as at close of Session, subject to expense of printing <i>Transactions</i>	65 4 7
	<hr/>
Total Funds	£270 4 3

	Brought forward,	£270	4	3
Being :—£200 5% War Stock, 1929-1947,				
at cost	£194	18	3	
Sum in Current Account with				
Union Bank of Scotland, Ltd. .	7	1	0	
Sum in Deposit Receipt with do.	70	0	0	
	£271	19	3	
Less—Subscriptions received in advance	1	15	0	
	As above .	£270	4	3

Note.—Subscriptions in arrear, considered recoverable : 1921-22, £1 10s. ; 1922-23, £3.

EDINBURGH, 6th October 1923.—I hereby certify that I have audited the Accounts of the Treasurer of the Botanical Society of Edinburgh for Session 1922-1923, and have found them correct. I have also checked the foregoing Abstract, and find it correct.

ROBT. C. MILLAR, C.A., Auditor.

Mr. F. A. HARDY was elected a Resident Fellow.

Mr. J. B. STEVENSON was elected a Non-Resident Fellow.

Miss OONA REID read a paper on the Propagation of Camphor by Stem Cuttings (see vol. xxviii, p. 184).

Miss EDITH PHILIP SMITH read a paper on the Germination of *Garcinia ovalifolia*, Oliver (see p. 15).

Mr. W. E. EVANS exhibited on behalf of Dr. G. CLARIDGE DRUCE a specimen of *Hieracium pulmonarioides*, Vill., found as an adventive at Kenmore in August 1923, and a specimen of *Carex microglochin*, Wahl., found for the first time in Britain by Lady Davy in Glen Lyon, 25th July 1923 (see p. 1). He also showed for comparison other *Carices* of the same section.

Dr. R. J. D. GRAHAM exhibited bulbs of *Ornithogalum* and Hyacinth showing profuse bulbil development (see p. 69).

The following plants in flower were shown from the Royal Botanic Garden :—*Bulbophyllum grandiflorum*, Blume ; *Chirita tubulosa*, Craib ; *Euphorbia lophogona*, Lam. ; *Liparis bootanensis*, Griff. ; *Paphiopedilum Godefroyae*, Pfitz. ; *Phaius pauciflorus*, Blume ; *Platyclinis uncata*, Benth. ; *Seraphyta multiflora*, Fisch. et Mey. ; *Spathicarpa sagittifolia*, Schott ; *Stapelia hirsuta*, Linn. ; *Symphyonema montanum*, R. Br.

NOVEMBER 15, 1923.

Professor W. WRIGHT SMITH, M.A., F.L.S., F.R.S.E., President,
in the Chair.

Miss OONA REID was elected a Resident Fellow.

Mr. FREDERICK STERN was elected a Non-Resident Fellow.

Mr. JOHN ANTHONY, Miss A. FYFE, Miss IRIS MAXWELL,
Miss B. C. MILLAR, and Mr. GEORGE TAYLOR were elected
Ordinary Members.

Mr. M. Y. ORR read a Note on Abnormal Fruits of *Erysimum*
Cretzianum (see p. 10).

Dr. MALCOLM WILSON read a Note on *Scleroderris livida*,
Massee, a fungus which has now been found attacking the
Douglas Fir.

Professor W. WRIGHT SMITH read a paper on *Primula*
Pauliana and other new Primulas from China and Tibet and
exhibited dried specimens of the novelties (see p. 8).

The following plants in flower were shown from the Royal
Botanic Garden :—*Angraecum bilobum*, Lindl. ; *Campanula*
calceicola, W. W. Sm. ; *Coelogyne miniata*, Lindl. ; *Dendrobium*
amplum, Lindl. ; *D. cymbidioides*, Lindl. ; *Gentiana leptoclada*,
Balf. f. et Forrest ; *Justicia speciosa*, Roxb. ; *Laelia pumila*,
Reichb. f., var. *Dayana* ; *Macodes Petola*, Lindl. ; *Olearia*
ramulosa, Benth. ; *Paphiopedilum niveum*, Pfitz.

The Very Rev. Dr. PAUL exhibited specimens of *Azolla*
filiculoides which he had gathered at Worcester.

DECEMBER 20, 1923.

Professor W. WRIGHT SMITH, M.A., F.L.S., F.R.S.E., President,
in the Chair.

Mr. ALEX. NELSON and Dr. H. M. STEVEN were elected
Resident Fellows.

Miss K. MASSEY and Mr. JAMES TAYLOR were elected Non-
Resident Fellows.

Mr. R. B. ANDERSON, Miss INA J. BARCLAY, Miss LILY M.
CUNNINGHAM, and Mr. G. B. WALLACE were elected Ordinary
Members.

The PRESIDENT announced the death of Mr. THOMAS F. CHEESEMAN, a Corresponding Member of the Society.

Mr. GEORGE FORREST read a paper on Recent Botanical Exploration in Western China, in which he gave some account of his botanical discoveries in Yunnan and Tibet, especially among Rhododendrons and Primulas. He illustrated his paper with a fine series of lantern slides.

JANUARY 17, 1924.

Professor W. WRIGHT SMITH, M.A., F.L.S., F.R.S.E., President, in the Chair.

Mrs. W. AITKEN, Miss E. M. HENDERSON, and Dr. JAMES CURRIE were elected Resident Fellows.

Mr. ROBERT BROUGH was elected a Non-Resident Fellow.

Mr. L. B. STEWART read a paper on the Morphology and Propagation of *Gardenia* (see p. 41).

Miss EDITH PHILIP SMITH read a paper on the Vegetative Propagation of *Clematis* (see p. 17).

Mr. ARTHUR BENNETT communicated Notes on *Potamogeton* (see p. 45).

Dr. G. C. DRUCE communicated a paper on Scottish *Taraxaca* (see p. 4).

The following plants in flower were shown from the Royal Botanic Garden :—*Bulbophyllum barbigerum*, Lindl. ; *B. comosum*, Collett et Hemsl. ; *Candidea stenostegia*, Stapf ; *Cymbidium Edinensis* \times (= *C. Iris* \times *C. Coningsbyanum*) ; *Cynorchis compacta*, Reichb. f. ; *Dendrobium subclausum*, Rolfe ; *Eria rosea*, Lindl. ; *Oncidium cucullatum*, Lindl. ; *Xylobium scabrilingue*, Rolfe.

FEBRUARY 21, 1924.

Professor W. WRIGHT SMITH, M.A., F.L.S., F.R.S.E., President, in the Chair.

Miss J. M'CALLUM was elected an Ordinary Member.

The PRESIDENT announced the death of Dr. WILLE, an Honorary Foreign Fellow.

Mr. J. A. ALEXANDER communicated a paper on a Visit to Ritigala Mountain.

Miss E. M. HENDERSON read a paper on the Stem Structure of *Sargentodoxa cuneata*, Rehd. et Wils. (see p. 57).

Miss M. M. B. KNAGG read a paper on the Leaf Structure of *Begonia fuchsioides*, Hook. (see p. 63).

Mr. J. MONTAGU DRUMMOND read a paper on Crop Breeding in Scotland, in which he indicated some of the points of contact between the practical art of Crop Breeding and the pure science of Botany. He illustrated his paper by a series of lantern slides.

MARCH 20, 1924.

Professor W. WRIGHT SMITH, M.A., F.L.S., F.R.S.E., President,
in the Chair.

Mr. ALEX. NELSON read a paper on Hard Seeds in Clover (see p. 66).

Dr. MALCOLM WILSON read a paper on the Relation of Pathology to Silviculture.

Mr. J. A. ALEXANDER communicated a paper on the Cultivation and Preparation of Rubber.

The following plants in flower were shown from the Royal Botanic Garden :—*Arisaema bicauculatum*, W. W. Sm.; *Barosma betulina*, Bartl. et Wendl. f.; *Coelia Baueriana*, Lindl.; *Cyclamen Atkinsii*, J. Moore; *Kennedya prostrata*, R. Br.; *K. nigricans*, Lindl.; *Pieris taiwanensis*, Hayata; *Raphiolepis Delacourii*, Hort.; *Soldanella hungarica*, Simonk.; *Tetralthea pilosa*, Labill.

MAY 1, 1924.

W. G. SMITH, B.Sc., Ph.D., in the Chair.

Miss HELEN M. BROWN and Mr. GEORGE HENDERSON were elected Non-Resident Fellows.

The CHAIRMAN announced the death of Professor EUGENE WARMING, an Honorary Foreign Fellow, and also of Mr. CHARLES S. S. JOHNSTON and Mr. R. GLODE GUYER, two Resident Fellows.

Dr. W. G. SMITH read an obituary notice of Professor EUGENE WARMING (see p. 113).

Mr. E. J. A. STEWART read a paper, by himself and Dr. D. PATTON, entitled Additional Notes on the Flora of the Culbin Sands (see p. 27).

Mr. ARTHUR BENNETT communicated Notes on Caithness Plants (see p. 54).

On behalf of Miss HAYWARD there were exhibited specimens of *Bidens pilosa* which had been found as a casual near Galashiels.

MAY 15, 1924.

Professor W. WRIGHT SMITH, M.A., F.L.S., F.R.S.E., President,
in the Chair.

The PRESIDENT announced the death of the Rev. W. W. PEYTON, a Resident Fellow.

Mr. J. R. SIMPSON communicated a paper on Some Moss Records for Selkirk (see p. 72).

Mr. L. B. STEWART read a paper on the Budding of *Acer* (see p. 43).

Dr. R. J. D. GRAHAM read a paper on the Vegetative Propagation of *Drimia* (see p. 69).

JUNE 19, 1924.

Professor W. WRIGHT SMITH, M.A., F.L.S., F.R.S.E., President,
in the Chair.

Col. H. H. JOHNSTON communicated a paper entitled Additions to the Flora of Orkney as recorded in Watson's Topographical Botany, 2nd ed., 1883 (see p. 83), and exhibited a number of interesting illustrative specimens collected by himself.

Miss C. J. KEAN read a paper on the Morphology and Physiology of the Leaves of some Crassulaceae (see p. 96).

Miss M. R. MITCHELL read a paper on the Petiolar "Lateral Lines" of Fern (see p. 105).

JULY 17, 18, 1924.

Professor W. WRIGHT SMITH, M.A., F.L.S., F.R.S.E., President,
in the Chair.

Under the superintendence of Dr. R. J. D. GRAHAM and Mr. L. B. STEWART there was arranged an exhibition of about three hundred species of seed-plants and two hundred photographs illustrating various methods of propagation from stem, root, and leaf.

Miss E. P. SMITH read a paper on the Propagation of Clematis (see p. 17).

Dr. R. J. D. GRAHAM read a paper on Propagation by Means of Leaves, in which he stated that from leaf cuttings of non-succulent dicotyledons the root system is first established, followed by the formation of the shoot, which however may be delayed, the time of its appearance depending to some extent on the viability of the leaf. In succulent dicotyledons and in monocotyledons the shoot buds appear before the formation of roots.

Dr. GRAHAM also read a paper on Propagation by Bulb Scales (see paper on *Ornithogalum* and *Drimia*, p. 69).

Mr. L. B. STEWART read a paper on Horizontal Branch Propagation (see paper on *Gardenia*, p. 41).

Mr. STEWART also read a paper on Root Cuttings, dealing specially with *Pelargonium* and *Acanthus montanus*. In the latter, juvenile or adult growth forms arise according to whether young or old portions of the root are used for cuttings (see vol. xxviii, p. 117).

The meetings were concluded by a general discussion of the practical side of the questions which had received attention, in which many visitors took part—both botanists and horticulturists.

PROCEEDINGS
OF THE
BOTANICAL SOCIETY OF EDINBURGH.

SESSION LXXXIX

OCTOBER 16, 1924.

Professor W. WRIGHT SMITH, M.A., F.L.S., F.R.S.E., President,
in the Chair.

The following Office-Bearers were elected for Session
1924-1925:—

PRESIDENT.

Professor W. WRIGHT SMITH, M.A., F.L.S., F.R.S.E.

VICE-PRESIDENTS.

A. W. BORTHWICK, O.B.E., D.Sc.	J. RUTHERFORD HILL, Esq.
J. MONTAGU F. DRUMMOND, B.A., F.L.S.	W. G. SMITH, B.Sc., Ph.D.

COUNCILLORS.

Miss ELSIE CADMAN, M.A., B.Sc.	Miss AUGUSTA LAMONT, B.Sc.
T. CUTHBERT DAY, Esq.	J. M. MURRAY, B.Sc.
W. EDGAR EVANS, B.Sc., F.R.S.E.	ALEX. NELSON, B.Sc.
SYMINGTON GRIEVE, Esq.	MALCOLM WILSON, D.Sc., F.L.S., F.R.S.E.
Miss ISABELLA KING, B.Sc.	WILLIAM YOUNG, Esq.

Honorary Secretary—J. R. MATTHEWS, M.A., F.L.S., F.R.S.E.

Foreign Secretary—Very Rev. D. PAUL, M.A., D.D., LL.D.

Treasurer—ANDREW MASON, Esq., c/o RICHARD BROWN & Co., C.A.

Assistant-Secretary—J. T. JOHNSTONE, M.A., B.Sc.

Artist—Professor FRANCIS M. CAIRD, M.B., C.M., F.R.C.S.E.

Auditor—ROBERT C. MILLAR, C.A.

The TREASURER, Mr. ANDREW MASON, submitted the following Statement of Accounts for Session 1923-1924:—

INCOME.

Annual Subscriptions for 1923-1924	£40	0	0
Do. Arrears	2	5	0
Transfer from Life Members' Fund	19	1	2
<i>Transactions</i> sold	11	10	6
Interest on Funds Invested and in Bank	11	14	2
Subscriptions to Publications Fund	6	15	0
	<hr/>		
	£91	5	10

EXPENDITURE.

Printing <i>Transactions</i> for Session 1922-1923	£47	19	4
Printing and Postage of Notices for Meetings, etc.	21	14	1
Rooms for Meetings and Tea	11	16	4
Hire of Lantern	1	11	3
Stationery, Postages, Carriages, etc.	3	3	9
Fire Insurance on Books, etc.	0	5	0
Honorarium to Treasurer	3	3	0
	<hr/>		
	£89	12	9
Excess of Income over Expenditure	£1	13	1

STATE OF FUNDS.

Life Members' Fund.

Balance of Fund at close of Session 1922-1923	£204	19	8
<i>Add</i> —Life compositions received	49	7	0
	<hr/>		
	£254	6	8
<i>Deduct</i> —Transferred to Income	19	1	2
	<hr/>		
Balance as at close of Session	£235	5	6

Ordinary Fund.

Balance of Fund at close of Session 1922-1923	£65	4	7
<i>Add</i> —Increase during Session 1923-1924	1	13	1
	<hr/>		
Balance as at close of Session, subject to expense of printing <i>Transactions</i>	66	7	8
	<hr/>		
Total Funds	£302	3	2

	Brought forward,	£302	3	2
Being :—£200 5% War Stock, 1929–1947,				
at cost	£194	18	3	
Sum in Current Account with				
Union Bank of Scotland, Ltd.	7	9	11	
Sum in Deposit Receipt with do.	100	0	0	
	£302	8	2	
Less—Subscription received in advance	0	5	0	
	As above	£302	3	2

Note.—Subscriptions in arrear, considered recoverable: 1922–23, 15s.; 1923–24, £4, 15s.

EDINBURGH, 3rd October 1924.—I hereby certify that I have audited the Accounts of the Treasurer of the Botanical Society of Edinburgh for Session 1923–1924, and have found them correct. I have also checked the foregoing Abstract, and find it correct.
ROBT. C. MILLAR, C.A., Auditor.

MR. JAMES ARCHIBALD FERGUSON was elected a Resident Fellow.

MISS A. M. DICKSON was elected an Ordinary Member.

THE PRESIDENT intimated the death on 15th September of JAMES GRIEVE, who had been a Fellow since 1889 and had served on the Council of the Society.

DR. R. S. MACDOUGALL exhibited (i) *Dactylopius coccus* (*Coccus Cacti*) on *Nopalea cochinillifera* from the Canary Islands, (ii) Galls of *Cynips quercus-tozae* from the South of France, and (iii) specimens of *Scolytus Ratzeburghi* and its work on Birch from Stobs.

DR. R. J. D. GRAHAM exhibited *Cladophora* balls collected in South Uist by Mr. Lee.

THE following plants in flower were shown from the Royal Botanic Garden :—*Aeschynanthus bracteata*, Wall. ; *Amasonia calycina*, Hook. f. ; *Coelogyne ovalis*, Lindl. ; *C. Veitchii*, Rolfe ; *Crassula impressa*, N.E.Br. ; *Cymbidium erythrostylum*, Rolfe ; *Epidendrum vitellinum*, Lindl., var. *majus* ; *Erica cerinthoides*, Linn. ; *Hoheria populnea*, A. Cunn. ; *Polystachya grandiflora*, Lindl. ; *Primula effusa*, W. W. Sm. et Forrest ; *Sedum Chaneti*, Lévl. ; and in fruit, *Solanum barbisetum*, Nees.

FEBRUARY 19, 1925.

Professor W. WRIGHT SMITH, M.A., F.L.S., F.R.S.E., President,
in the Chair.

Mr. J. ANDERSON, Mr. F. W. SANSOME, and Mr. JAMES MACDONALD were elected Resident Fellows.

Miss ANNIE M. WATTS was elected an Ordinary Member.

The PRESIDENT announced the death of Dr. JOHN FRASER, a Resident Fellow of the Society.

Mr. AHMED RIFAT read a paper on the Structure and Germination of the Egyptian Cotton Seed.

Mr. J. M. MURRAY, Mr. J. R. MATTHEWS, and Mr. HARROW each exhibited a number of examples of Fasciation.

Mr. J. RUTHERFORD HILL exhibited a cone of *Pinus Pinea*, Linn., from a tree growing near Cockburnspath.

Mr. M. Y. ORR exhibited Witches' Broom on *Pinus sylvestris*, Linn., and also Wood of Larch showing effects of frost.

Dr. MALCOLM WILSON exhibited a specimen of *Pinus sylvestris* showing successional disease.

The following plants in flower were shown from the Royal Botanic Garden :—*Cotyledon fulgens*, Baker; *Cyclamen Atkinsii* ×, T. Moore; *Cymbidium Edinense*, Hort.; *Erica laevis*, Andr.; *Hamamelis mollis*, Oliv.; *Manettia luteo-rubra*, Benth.; *Pelargonium crithmifolium*, Sm.; *Rhododendron arboreum*, Sm.; *Rh. mucronulatum*, Turcz.; *Rh. parvifolium*, Adams; *Saxifraga Burseriana*, Linn., var. *major*; *Trias picta*, Benth.

MARCH 19, 1925.

Professor W. WRIGHT SMITH, M.A., F.L.S., F.R.S.E., President,
in the Chair.

Miss JEAN E. GRIEVE, Mr. JAMES WATT, Miss C. I. KEAN, and Mr. AHMED RIFAT were elected Resident Fellows.

Mr. LIONEL N. DE ROTHSCHILD was elected a Non-Resident Fellow.

The PRESIDENT announced the death of Dr. CLELAND, who had been a Non-Resident Fellow since 1856.

Mr. J. S. L. WALDIE read a Note on *Cladochytrium myriophylli*, Rostr., a new British record.

Mr. J. W. GREGOR read a paper on the Pollination and Fertilisation of Grasses, which he illustrated by a number of lantern slides.

Mr. T. CUTHBERT DAY exhibited an abnormal fruit of Barley.

Mr. J. M. MURRAY exhibited specimens showing proliferation of *Picea exelsa*, *Larix europaea*, *Pinus monticola*, *Abies nobilis*, and *Larix leptolepis*.

Dr. MALCOLM WILSON and Mrs. ALCOCK exhibited specimens of *Coleosporium senecionis*, *Phragmidium fragariastris*, *Puccinia mirabilissima*, and *Fomes annosus*.

Miss ISABELLA M. KING exhibited a section of an *Acer* stem having a curious trefoil mark probably caused by a fungus.

The following plants in flower were shown from the Royal Botanic Garden :—*Androsace pyrenaica*, Lam. ; *Bryophyllum calycinum*, Salisb. ; *Dracophyllum secundum*, R. Br. ; *Phalaenopsis Lueddemanniana*, Rchb. f. ; *Pittosporum Tobira*, Ait. ; *Platyclinis rufa*, Rolfe ; *Pleurothallis astrophora*, Rchb. f. ; *Rhododendron argenteum*, Hook. f. ; *Rh. irroratum*, Franch. ; *Rh. phoeniceum*, G. Don, var. *tebotan*, Wilson ; *Sarcochilus Fitzgeraldii*, F. Muell. ; *Saxifraga Stribrnyi*, Podpera ; *Scaphyglottis Behrii*, Hort. ; *Streitzia Reginae*, Ait.

APRIL 30, 1925.

Professor W. WRIGHT SMITH, M.A., F.L.S., F.R.S.E., President,
in the Chair.

Mr. W. DAWSON, Mr. WM. R. M'ILVENNA, Mr. ERIC KNOTT, Mr. FREDERICK W. ROBERTSON, Mrs. MARJORY F. ROBERTSON, and Mr. THOMAS ARTHUR SMITH were elected Ordinary Members.

Dr. R. J. D. GRAHAM read a paper on the Effects of Inverting Bulbs of the Wild Hyacinth.

Dr. GRAHAM and Mr. L. B. STEWART exhibited bulbs of *Albuca Nelsoni*, *Bowea volubilis*, *Vallota purpurea*, and others, showing induced bud-formation.

Mr. J. RUTHERFORD HILL exhibited some camphor extracted from a plant grown at the Royal Botanic Garden, and gave the results of analysis of the leaves and stem.

MAY 21, 1925.

Professor W. WRIGHT SMITH, M.A., F.L.S., F.R.S.E., President,
in the Chair.

Sir EVERARD IM THURN was elected a Resident Fellow.

Miss JANE LOW and Miss ELIZABETH B. PARROTT were
elected Ordinary Members.

Miss ELLEN B. HENDERSON contributed a paper on a
Diatomaceous Deposit at Dalmahoy (see p. 135), which was
illustrated by photographs of the prevailing species.

Miss EDITH PHILIP SMITH read a paper on the Origin of
Adventitious Growths in *Coleus* (see p. 145).

Mr. L. B. STEWART exhibited a specimen of *Eriodendron*
anfractuosum showing the effect of pruning.

JUNE 19, 1925.

Professor W. WRIGHT SMITH, M.A., F.L.S., F.R.S.E., President,
in the Chair.

Mr. J. R. MATTHEWS and Miss E. M. HENDERSON com-
municated a paper on the Staminal Structure of Certain
Ericaceae.

Col. H. H. JOHNSTON communicated a paper entitled
Additions to the Flora of Orkney as recorded in Watson's
Topographical Botany, 2nd ed. (1883) (see p. 151), and
exhibited a number of interesting illustrative specimens
collected by himself.

Col. H. H. JOHNSTON also communicated a paper entitled
Observations on "*Ceratophyllum demersum*, Linn., in the
Orkney Isles. By Arthur Bennett, A.L.S." (Trans. Bot. Soc.
Edin., vol. xxvii (1917), p. 134), in which he disposes of the
record of *Ceratophyllum demersum* for Orkney—the specimens
upon which it was founded being now identified as *Utricularia*
major, Schmidel, a plant which Col. Johnston has previously
recorded for Orkney.

Miss NORAH CUMMING read a paper on *Atriplex Babingtonii*,
Woods (see p. 171).

Mr. WM. G. CAMPBELL read a paper on An Exoascus Disease
of the Almond (see p. 186).

Mr. JOHN F. DUNCAN read a paper on the Pull-Roots of
Oxalis esculenta (see p. 192).

PROCEEDINGS
OF THE
BOTANICAL SOCIETY OF EDINBURGH.

SESSION XC

OCTOBER 15, 1925.

Professor W. WRIGHT SMITH, M.A., F.L.S., F.R.S.E., President,
in the Chair.

The following Office-Bearers were elected for Session
1925-1926:—

PRESIDENT.

Professor MONTAGU DRUMMOND, M.A., F.L.S., F.R.S.E.

VICE-PRESIDENTS.

R. A. ROBERTSON, M.A., B.Sc.

Professor W. WRIGHT SMITH, M.A.,
F.L.S., F.R.S.E. [F.R.S.E.]

W. G. SMITH, B.Sc., Ph.D.

MALCOLM WILSON, D.Sc., F.L.S.,

COUNCILLORS.

T. CUTHBERT DAY, F.I.C.

Miss AUGUSTA LAMONT, B.Sc.

W. EDGAR EVANS, B.Sc., F.R.S.E.

J. M. MURRAY, B.Sc.

SYMINGTON GRIEVE, Esq.

ALEX. NELSON, B.Sc.

ANDREW HARLEY, Esq.

J. RUTHERFORD HILL, Esq.

Miss E. PHILIP SMITH, B.A.,
Ph.D., F.L.S.

Miss ISABELLA M. KING, B.Sc.

Honorary Secretary—J. R. MATTHEWS, M.A., F.L.S., F.R.S.E.

Foreign Secretary—Very Rev. D. PAUL, M.A., D.D., LL.D.

Treasurer—ANDREW MASON, Esq., c/o RICHARD BROWN & Co., C.A.

Assistant-Secretary—J. T. JOHNSTONE, M.A., B.Sc.

Artist—Professor FRANCIS M. CAIRD, M.B., C.M., F.R.C.S.E.

Auditor—ROBERT C. MILLAR, C.A.

The TREASURER, Mr. ANDREW MASON, submitted the following Statement of Accounts for Session 1924-1925:—

INCOME.

Annual Subscriptions for 1924-1925	£48 15 0
Do. Arrears	2 5 0
Transfer from Life Members' Fund	19 12 8
<i>Transactions</i> sold	8 0 6
Interest on Funds Invested and in Bank	12 4 8
Subscriptions to Publications Fund	28 18 6
Income from Botanical Society Trust Fund	7 18 9
	<hr/>
	£127 15 1

EXPENDITURE.

Printing <i>Transactions</i> for Session 1923-1924	£89 8 1
Printing and Postage of Notices for Meetings, etc. . . .	18 12 0
Rooms for Meetings and Tea	11 0 8
Stationery, Postages, Carriages, etc. . . .	4 1 8
Fire Insurance on Books, etc. . . .	0 5 0
Honorarium to Treasurer	3 3 0
	<hr/>
	£126 10 5
Excess of Income over Expenditure	<hr/>
	£1 4 8

STATE OF FUNDS.

Life Members' Fund.

Balance of Fund at close of Session 1923-1924	£235 5 6
Add—Life compositions received	29 8 0
	<hr/>
	£264 13 6
Deduct—Transferred to Income	19 12 8
	<hr/>
Balance as at close of Session	£245 0 10

Ordinary Fund.

Balance of Fund at close of Session 1923-1924	£66 17 8
Add—Increase during Session 1924-1925	1 4 8
	<hr/>
Balance as at close of Session, subject to expense of printing <i>Transactions</i>	68 2 4
	<hr/>
Total Funds	£313 3 2

	Brought forward,	£313 3 2
Being :—£200 5% War Stock, 1929–1947,		
at cost	£194 18 3	
Sum in Current Account with		
Union Bank of Scotland, Ltd. .	15 14 11	
Sum in Deposit Receipt with do.	105 0 0	
	<hr/>	
	£315 13 2	
Less—Subscriptions received in advance	2 10 0	
	<hr/>	
	As above .	<u>£313 3 2</u>

Note.—Subscriptions in arrear, considered recoverable : 1923–24, £1, 15s. ; 1924–25, £3, 10s.

EDINBURGH, 7th October 1925.—I hereby certify that I have audited the Accounts of the Treasurer of the Botanical Society of Edinburgh for Session 1924–1925, and have found them correct. I have also checked the foregoing Abstract, and find it correct.

ROBT. C. MILLAR, C.A., Auditor.

BOTANICAL SOCIETY TRUST FUND.

INCOME.	
Interest on Funds invested	£8 10 6
<hr/>	
EXPENDITURE.	
Stationery	£0 11 9
To Publications Fund	7 18 9
	<hr/>
	8 10 6

EDINBURGH, 2nd October 1925.—I have examined the books and vouchers of the Edinburgh Botanical Society Trust Fund, and certify the same to be correct.

MATTHEW LAWSON.

Miss EDITH MERCER and Miss JOHNSTON were elected Resident Fellows.

Mr. WM. LOW was elected a Non-Resident Fellow.

Dr. R. LLOYD PRAEGER communicated a paper on Canarian and Madeiran Semperviva (see p. 199).

Mr. HARROW exhibited a large number of Canarian and Madeiran Semperviva (including a few in flower) to illustrate Dr. Praeger's paper.

A discussion on "Evolution in the Light of Hybridisation" was introduced by Mr. J. R. MATTHEWS, and carried on by Mr. Rutherford Hill, Dr. Graham, Mr. Buchanan, Dr. E. Philip Smith, Dr. Borthwick, and Professor Wright Smith.

Mrs. ALCOCK read a note on Raspberry Canker (*Nectria rubi*, Osterwalder), and exhibited some specimens of diseased Raspberry roots.

NOVEMBER 19, 1925.

J. RUTHERFORD HILL, Esq., in the Chair.

Mrs. DE PREE and Mr. JOHN S. L. WALDIE were elected Resident Fellows.

The following motion on Alteration of Laws, by Dr. R. J. D. GRAHAM, seconded by Mr. J. R. MATTHEWS, was carried unanimously :—

Chapter IV.—That there be added the following Law, to be intituled : Section VIII. *Balloting*.—In the foregoing sections, which relate to admission of members to the Society, the Council shall have power to recommend admission without ballot, unless such ballot is demanded by giving written notice to the Hon. Secretary two days before the date of proposed election. Any such ballot will be taken at the next ordinary meeting of the Society.

The following motion on Alteration of Laws, by the HON. SECRETARY, seconded by Dr. R. J. D. GRAHAM, was carried unanimously :—

Chapter V. *Office-Bearers*.—That paragraph 6 be altered to read : The Council shall appoint annually three of their number, including the Honorary Secretary, who shall have power to co-opt additional referees, if necessary, to act as editors and superintend the printing of the *Transactions*.

The Chairman announced the death of Professor MASSART, an Honorary Foreign Fellow (see p. 308), and of JAMES SYKES GAMBLE, a Resident Fellow.

Mr. J. R. MATTHEWS read a paper on Fife and Kinross Roses (see p. 219).

Dr. E. PHILIP SMITH read a paper on the Relation of Acidity to Rooting in *Coleus*.

Dr. R. J. D. GRAHAM read a paper on a Bud Variation of *Rhus tomentosa*.

Mrs. N. L. ALCOCK exhibited Ferns attacked by Eelworm (*Aphelencus olesistus*).

The following plants in flower were shown from the Royal Botanic Garden :—*Acacia alata*, R. Br. ; *Cochlioda vulcanica*, Benth. et Hook. f. ; *Crassula Bolusii*, Hook. f. ; *Cyperorchis Mastersii*, Benth. ; *Dendrobium Victoriae-Reginae*, Loher ; *Dermatobotrys Saundersii*, Bolus ; *Epidendrum vitellinum*, Lindl. ; *Grevillea alpina*, Lindl. ; *Masdevallia Laucheana*, Hort. Sander ; *M. polysticta*, Reichb. f. ; *M. towarensis*, Reichb. f. ; *Sarauja macrophylla*, Hort. ; and *Trichosma suavis*, Lindl.

DECEMBER 17, 1925.

Professor MONTAGU DRUMMOND, M.A., F.L.S., F.R.S.E.,
President, in the Chair.

Miss A. W. MACKIE, Miss E. I. NOBLE, and Mr. A. E. S. M'INTOSH were elected Resident Fellows.

Dr. A. W. BORTHWICK read a paper on a Forestry Tour in Canada, illustrated by a large number of lantern slides, describing the different types of Forest in Canada, the methods of lumbering used there, and the utilisation of the products.

JANUARY 21, 1926.

Professor W. WRIGHT SMITH, M.A., F.L.S., F.R.S.E.,
Vice-President, in the Chair.

Mr. JAMES W. GREGOR and Dr. MARK L. ANDERSON were elected as Resident Fellows.

The Chairman announced the death of Mr. J. H. MAIDEN, late Director of the Botanic Garden, Sydney, a Corresponding Member of the Society.

Dr. MALCOLM WILSON exhibited *Lentinus lepideus* which had been growing on a pit prop in a Fife coal-mine.

Mr. R. M. ADAM exhibited a number of lantern slides illustrating the damage caused to trees at Murthly by the recent snowstorm.

Mr. L. B. STEWART exhibited a specimen of leaf variation in *Acrostichum scandens*.

Mr. J. R. MATTHEWS communicated a note on the Flora of Salisbury Crags (see p. 226).

Professor JAMES SMALL communicated a paper describing *Wardaster*, a new genus of Compositae (see p. 230).

FEBRUARY 18, 1926.

Professor W. WRIGHT SMITH, M.A., F.L.S., F.R.S.E.,
Vice-President, in the Chair.

Mr. WILLIAM ROBB was elected a Resident Fellow.

The Chairman announced the death of Mr. JAMES WHYTOCK, a former President of the Society (see p. 309).

Miss ELSIE CADMAN exhibited Tulip Bulbs, collected in the vicinity of Edinburgh, attacked by the fungus *Rhizoctonia tuliparum* (Klebahn), Whetz. et Arth. This fungus causes considerable damage in the bulb fields of Holland, and has also been described in America. No previous record of its occurrence in Scotland has been found, but it has probably been confused here with other sclerotium-forming fungi which infest the tulip.

Dr. R. STEWART MACDOUGALL exhibited some Crop Pests spread in Commerce.

The following plants in flower were shown from the Royal Botanic Garden:—*Corylopsis Willmottiae*, Rehd. et Wils.; *Crassula rosularis*, Haw.; *Odontoglossum naevium*, Lindl.; *Physosiphon Moorei*, Rolfe; *Pieris japonica*, D. Don; *Platyclinis rufa*, Rolfe; *Pleurothallis Roezlii*, Reichb. f.; *Primula Winteri*, Wats.; *Saxifraga Burseriana*, Linn., var. *gloria*; *Sedum bellum*, Rose; *Sophronitis grandiflora*, Lindl.; *Trias picta*, Benth.

Mr. J. R. MATTHEWS and Mr. GEORGE TAYLOR communicated a paper on the Structure and Development of the Stamen in *Erica hirtiflora* (see p. 235).

Mr. J. R. MATTHEWS and Mrs. E. M. KNOX communicated a paper on the Comparative Morphology of the Stamen in the Ericaceae (see p. 243).

MARCH 18, 1926.

Professor MONTAGU DRUMMOND, M.A., F.L.S., F.R.S.E.,
President, in the Chair.

Mr. ROBERT MORRISON was elected an Ordinary Member.

The President announced the death of Mr. ALEXANDER WADDELL, who had been a Non-Resident Fellow since 1886.

Mr. F. W. SANSOME and Mr. J. W. GREGOR read a paper on the Genotypic Response of Plant Species to the Habitat, which they illustrated by a number of lantern slides.

Mrs. N. L. ALCOCK read a paper on an undescribed form of *Phytophthora* on *Atropa Belladonna*, which was illustrated by lantern slides.

APRIL 22, 1926.

Professor W. WRIGHT SMITH, M.A., F.L.S., F.R.S.E.,
Vice-President, in the Chair.

The Rt. Hon. LORD CARDROSS and Mr. JOSEPH JOHN BLACKIE were elected Resident Fellows.

Mr. JOHN ANTHONY read a paper on Two Undescribed Species of *Codonopsis*, giving descriptions of *C. Farreri* and *C. chimiliensis*, and exhibited a number of different species of that genus.

Mr. JOHN S. L. WALDIE exhibited specimens of conifers showing damage due to *Fomes annosus* (Fr.) Cooke—(1) on eight-year-old Corsican pine with the fructifications round the base of the stem; (2) causing Heart-rot in Douglas fir, Japanese larch, and Norway spruce, accompanied by the characteristic lilac or purplish tint of the timber and the presence of white patches preceding the final rot or "pumping" of the stem. A specimen of *Crataegus oxyacantha* attacked by *F. annosus* was also exhibited.

Dr. E. PHILIP SMITH exhibited and explained an apparatus for the determination of oxygen-consumption by plants.

Mr. GEORGE TAYLOR exhibited living specimens of *Volvox*.

MAY 20, 1926.

Professor W. WRIGHT SMITH, M.A., F.L.S., F.R.S.E.,
Vice-President, in the Chair.

Miss IRIS MAXWELL was elected a Non-Resident Fellow.

Mr. ALEX. NELSON communicated a paper on Hard Seeds and Broken Seedlings in Red Clover. II. Storage Problems (see p. 282).

Mr. GEORGE TAYLOR read a paper on the Origin of Adventitious Growths in *Acanthus*, which he illustrated with a number of microscopic slides and photographs (see p. 291).

Mr. A. E. S. M'INTOSH exhibited specimens from Blairgowrie of Blossom-wilt and Wither-tip of Victoria Plum, caused by the fungus *Monilia cinerea* f. *pruni*.

Mr. J. R. MATTHEWS exhibited from Bridge of Allan specimens of *Neottia nidus-avis*, *Pyrola minor*, and *Paris quadrifolia*.

JUNE 17, 1926.

Professor W. WRIGHT SMITH, M.A., F.L.S., F.R.S.E.,
Vice-President, in the Chair.

The CHAIRMAN announced the death of Mr. T. BENNET CLARK, a former President of the Society (see p. 308).

Col. H. H. JOHNSTON communicated a paper entitled Additions to the Flora of Orkney, as recorded in "Watson's Topographical Botany," 2nd ed. (1883) (see p. 297), which was illustrated by a number of interesting specimens collected by himself.

Dr. MALCOLM WILSON exhibited a hybrid Geum raised by the late Dr. Ford Robertson. The original cross was *Geum rivale*, Linn. \times *Geum coccineum* var. Mrs. Bradshaw. This produced a plant with moderately large yellow petals which set seed. One plant of the F₂ generation possessed flowers with yellow petals tinged with red, and was partially double.

PROCEEDINGS

OF THE

BOTANICAL SOCIETY OF EDINBURGH.

SESSION XCI

OCTOBER 21, 1926.

Professor MONTAGU DRUMMOND, M.A., F.L.S., F.R.S.E., President,
in the Chair.

The following Office-Bearers were elected for Session
1926-1927 :—

PRESIDENT.

Professor MONTAGU DRUMMOND, M.A., F.L.S., F.R.S.E.

VICE-PRESIDENTS.

T. CUTHBERT DAY, F.I.C.

Professor W. WRIGHT SMITH, M.A.,
F.L.S., F.R.S.E. [F.R.S.E.

W. EDGAR EVANS, B.Sc., F.R.S.E.

MALCOLM WILSON, D.Sc., F.L.S.,

COUNCILLORS.

D. ARMSTRONG, Esq.

J. M. MURRAY, B.Sc.

JAMES W. GREGOR, Ph.D.

ALEX. NELSON, B.Sc.

SYMINGTON GRIEVE, Esq.

Miss E. PHILIP SMITH, B.A.,
Ph.D., F.L.S.

ANDREW HARLEY, Esq.

J. RUTHERFORD HILL, Esq.

W. G. SMITH, B.Sc., Ph.D.

Miss ISABELLA M. KING, B.Sc.

Honorary Secretary—J. R. MATTHEWS, M.A., F.L.S., F.R.S.E.

Foreign Secretary—Very Rev. D. PAUL, M.A., D.D., LL.D.

Treasurer—ANDREW MASON, Esq., c/o RICHARD BROWN & Co., C.A.

Assistant-Secretary—J. T. JOHNSTONE, M.A., B.Sc.

Artist—Professor FRANCIS M. CAIRD, M.B., C.M., F.R.C.S.E.

Auditor—ROBERT C. MILLAR, C.A.

The TREASURER, Mr. ANDREW MASON, submitted the following Statement of Accounts for Session 1925-1926:—

INCOME.

Annual Subscriptions for 1925-1926	£48 15 0
Do. Arrears	2 10 0
Transfer from Life Members' Fund	20 2 0
Transactions sold	8 4 11
Interest on Funds Invested and in Bank	12 19 3
Subscriptions to Publications Fund	36 13 6
Income from Botanical Society Trust Fund	17 14 1

£146 18 9

EXPENDITURE.

Printing <i>Transactions</i> for Session 1924-1925	£74 18 5
Printing and Postage of Notices for Meetings, etc.	19 17 0
Rooms for Meetings and Tea	13 5 1
Hire of Lantern	1 12 3
Stationery, Postages, Advertising, etc.	6 10 10
Fire Insurance on Books, etc.	0 5 0
Honorarium to Treasurer	3 3 0

£119 11 7

Excess of Income over Expenditure

£27 7 2

STATE OF FUNDS.

Life Members' Fund.

Balance of Fund at close of Session 1924-1925	£245 0 10
Add—Life compositions received	38 17 0

£283 17 10

Deduct—Transferred to Income

20 2 0

Balance as at close of Session

£263 15 10

Ordinary Fund.

Balance of Fund at close of Session 1924-1925	£68 2 4
Add—Increase during Session 1925-1926	27 7 2

Balance as at close of Session, subject to expense of printing *Transactions*

95 9 6

Total Funds

£359 5 4

	Brought forward,	£359	5	4
Being :—£200 5% War Stock, 1929–1947,				
at cost	£194	18	3	
Sum in Current Account with				
Union Bank of Scotland, Ltd. .	10	2	1	
Sum in Deposit Receipt with do.	155	0	0	
	£360	0	4	
Less—Subscriptions received in advance	0	15	0	
	As above .	£359	5	4

Note.—Subscriptions in arrear, considered recoverable: 1923–24, 15s.; 1924–25, 15s.; 1925–26, £5, 10s.

EDINBURGH, 12th October 1926.—I hereby certify that I have audited the Accounts of the Treasurer of the Botanical Society of Edinburgh for Session 1925–1926, and have found them correct. I have also checked the foregoing Abstract, and find it correct.

ROBT. C. MILLAR, C.A., Auditor.

BOTANICAL SOCIETY TRUST FUND.

INCOME.

Interest on Funds invested	£17	14	1
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EXPENDITURE.

To Publications Fund	£17	14	1
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EDINBURGH, 6th October 1926.—I have examined the books and vouchers of the Edinburgh Botanical Society Trust Fund, and certify the same to be correct.

MATTHEW LAWSON.

MR. WILLIAM C. CALLENDER, MR. V. E. M. DAVY, and MR. GEORGE TAYLOR were elected Resident Fellows.

MISS LOGAN HOME was elected a Non-Resident Fellow.

The PRESIDENT, Professor MONTAGU DRUMMOND, delivered his Presidential Address: Some Reflections on the Nature of Species (see p. 311).

The following plants in flower were shown from the Royal Botanic Garden:—*Amasonia calycina*, Hook. f.; *Bulbophyllum grandiflorum*, Blume; *Callicarpa purpurea*, Juss.; *Cirrhopetalum ornatissimum*, Reichb. f.; *Columnea gloriosa*, Sprague; *Eulophia guineensis*, Lindl.; *Fuchsia parviflora*, Lindl.; *Gurania malacophylla*, Rodr. (♂ and ♀); *Holmskioldia sanguinea*, Retz.; *Ixora amabilis*, Hort.; *Laelia pumila*, Reichb. f., var. *praestans*; *Mesembryanthemum Elishae*, N.E. Br.; *M. Leslei*, N.E. Br.; *M. stylosum*, N.E. Br.; *tigrinum*, Haw., var. *superbum*; *Momordica cochinchinensis*, Spreng.; *Nerine Bowdeni*, W. Watson, *Oncidium lanceanum*, Lindl.; *O. Papilio*, Lindl.; *Othonna carnos*a, Less., and *Pinguicula caudata*, Schlecht.

NOVEMBER 18, 1926.

Professor W. WRIGHT SMITH, M.A., F.L.S., F.R.S.E.,
Vice-President, in the Chair.

Mrs. SMITH was elected a Lady Member.

Mr. A. V. BEGG and Mr. JOHN ANTHONY were elected Resident Fellows.

Mr. H. GUTHRIE SMITH was elected a Non-Resident Fellow.

Miss J. S. CLARK, Miss D. DRYSDALE, Miss C. M. MAC-LACHLAN, Miss A. W. H. REDMAN, Miss M. H. SMITH, and Mr. G. A. STEVEN were elected Ordinary Members.

The Chairman announced the death of Emeritus Professor F. M. CAIRD, who had been a Resident Fellow since 1882, and was appointed Artist to the Society in 1892.

Dr. R. J. D. GRAHAM and Mr. L. B. STEWART communicated a paper on Regeneration in the Root of *Anchusa* (see p. 333).

Dr. MALCOLM WILSON and Mr. J. S. L. WALDIE communicated a paper on an Epidemic Disease of the Oak in Britain. The paper was illustrated by a number of lantern slides.

Mrs. N. L. ALCOCK exhibited a specimen of *Aster Tripolium* whose leaves were attacked by the fungus *Ramularia asteris*, Phill. et Plowr.

The following plants in flower were shown from the Royal Botanic Garden :—*Angraecum bilobum*, Lindl. ; *Calceolaria Pavonii*, Benth. ; *Cephalangraecum glomeratum*, Schlechter ; *Coelogyne miniata*, Lindl. ; *Colletia cruciata*, Gill. et Hook. ; *Cuphea micropetala*, H. B. K. ; *Dichorisandra thyrsiflora*, Mikan. ; *Grevillea Thelemanniana*, Hueg. ; *Liparis longipes*, Lindl. ; *Nerine candida*, Hort. ; *Phalaenopsis Esmeralda*, Reichb. f. ; *Phyllica ericoides*, Linn. ; *Platyclinis Cobbiana*, Hemsl. ; *P. uncata*, Benth. ; *Pleurothallis conanthera*, Reichb. f. ; *Polygala myrtifolia*, Linn., var. *grandiflora* ; *Polystachya puberula*, Lindl. ; *Restio subverticillatus*, Mast. ; *Saurauja macrophylla*, Hort. ; *Senecio juncus*, Harv., and *Vitis heterophylla*, Thunb., var. *humulifolia*.

DECEMBER 16, 1926.

T. CUTHBERT DAY, Esq., Vice-President, in the Chair.

Mrs. W. C. CALLENDER was elected a Lady Member.

The Rev. J. J. MARSHALL LANG AIKEN communicated the Report of the Scottish Alpine Botanical Club Excursion, 1925 (see p. 335).

Miss ELSIE CADMAN read a paper on the Mycetoza, with special reference to *Reticularia Lycoperdon*, which she illustrated with specimens and lantern slides.

The following plants in flower were shown from the Royal Botanic Garden:—*Angraecum distichum*, Lindl.; *Aphelandra fascinator*, Lind. et André; *Bulbophyllum auricomum*, Lindl.; *B. comosum*, Hemsl.; *Cirrhopetalum Makoyanum*, Reichb. f.; *Desmodium confertum*, DC.; *Masdevallia melanopus*, Reichb. f.; *Oncidium Croesus*, Reichb. f.; *Rivina humilis*, Linn.; *Senecio angulatus*, Linn. f., and *Trichopilia Gouldii* (*T. fragrans* × *suavis*).

JANUARY 20, 1927.

Professor W. WRIGHT SMITH, M.A., F.L.S., F.R.S.E.,
Vice-President, in the Chair.

The Chairman announced the death of Mr. ROBERT BROUGH, a Non-Resident Fellow.

Mr. GLENN GARDNER HAHN read a paper on Fungi as an International Problem (see p. 342), which he illustrated by a number of lantern slides and also exhibits.

Mr. GEORGE TAYLOR exhibited a number of interesting Scottish Plants.

The following plants in flower were shown from the Royal Botanic Garden:—*Angraecum maxillarioides*, Ridl.; *Aphelandra aurantiaca*, Lindl., var. *Roezlii*; *Coelogyne sulphurea*, Reichb. f.; *Coriaria nepalensis*, Wall.; *Cotyledon fulgens*, Baker; *Crassula lactea*, Ait.; *Cynorchis compacta*, Reichb. f.; *C. Lowiana*, Reichb. f.; *Echeveria multicaulis*, Rose;

Lindenbergia grandiflora, Benth.; *Ornithidium Sophronitis*, Reichb. f.; *Primula heterochroma*, Stapf; *P. Sibthorpii*, Hoffmgg.; *Saccolabium bellinum*, Reichb. f.; and *Sedum compressum*, Rose.

FEBRUARY 24, 1927.

Professor MONTAGU DRUMMOND, M.A., F.L.S., F.R.S.E.,
President, in the Chair.

Mr. GEORGE FORREST gave a lecture on his recent botanical explorations in Yunnan, mainly in the area adjoining the N.E. Burma frontier. He described the dense coniferous and hardwood forests which clothe the hills of the region and also the herbaceous flora of the hills among which many new forms were obtained. The lecture was illustrated by a long series of lantern slides.

MARCH 17, 1927.

Professor W. WRIGHT SMITH, M.A., F.L.S., F.R.S.E.,
Vice-President, in the Chair.

Mr. ROBERT L. GORRIE and Miss LUCY BOYD were elected Resident Fellows.

Mr. ALEX. NELSON read a paper on Methods of Seed Analysis, and illustrated it with a large number of exhibits.

Dr. R. J. D. GRAHAM read a paper, Studies in Wild Rice (*Oryza sativa*, Linn.). (See p. 349.)

Mr. John S. L. WALDIE gave a short account of recent work on diseases of conifers, illustrated with lantern slides.

Mr. J. R. MATTHEWS exhibited some Mosses, Liverworts and Ferns from Peeblesshire.

APRIL 28, 1927.

Professor W. WRIGHT SMITH, M.A., F.L.S., F.R.S.E.,
Vice-President, in the Chair.

Mr. J. R. ROBERTSON was elected a Resident Fellow.

The Chairman announced the death of Professor CHAS. S. SARGENT, an Hon. Foreign Fellow of the Society since 1895.

Miss LILY M. CUNNINGHAM read a paper, Observations on the Structure of *Zygophyllum Fabago*, Linn. (see p. 352), which she illustrated with drawings and models.

Mr. GEORGE D. FORBES communicated a paper on Propagation of *Hevea brasiliensis* in Malaya.

MAY 19, 1927.

Professor W. WRIGHT SMITH, M.A., F.L.S., F.R.S.E.,
Vice-President, in the Chair.

Mr. J. R. MATTHEWS read a paper, Recent Additions to the List of Perthshire Plants.

Dr. MALCOLM WILSON exhibited specimens of Douglas Fir attacked by *Rhabdochline Pseudotsugae* from Peeblesshire, and gave some account of the spread of this disease in Britain.

Mrs. N. L. ALCOCK exhibited microscopic preparations showing mycorrhiza in certain Ferns. She stated that during the course of experiments carried out in 1926-27 by the Board of Agriculture for Scotland for the control of bracken, a fungus was found in the roots that Dr. W. G. SMITH suggested was a mycorrhiza.

On further search this fungus was found to be present in the small roots a little way behind the growing tip of all the bracken examined. The bracken came from Glenorchy and Loch Awe, the Pentlands, Moffat Water, and Ayrshire in Scotland, and Somerset, England. Bracken was also obtained from Les Landes in France, and from near Nelson in New Zealand. In every case the mycorrhiza was found.

Other ferns were also examined and the mycorrhiza seen in the roots of *Aspidium Felix-mas*, Sw.; *A. spinulosum*, Sw.; *Blechnum spicant*, Roth; *Polypodium vulgare*, Linn.; *Adiantum Capillus Veneris*, Linn.; *Pteris cretica*, Linn.; and the tree fern *Dicksonia antarctica*, R. Br.

JUNE 16, 1927.

Professor W. WRIGHT SMITH, M.A., F.L.S., F.R.S.E.,
Vice-President, in the Chair.

Mr. E. H. CHATER communicated a paper on the Distribution of the Larger Brown Algae in Aberdeenshire Estuaries (see p. 362).

Miss C. I. KEAN read a paper on the Anatomy of the Genus *Mesembryanthemum*. 1. Root Structure (see p. 381).

Mr. J. WRIGHT read a paper, Notes on Strand Plants: *Cakile maritima* (see p. 389).

Mr. ALEX. NELSON read a paper on Hard Seeds and Broken Seedlings in Red Clover. III. Soil Effects (see p. 402).

Col. H. H. JOHNSTON communicated a paper on Additions to the Flora of Orkney as recorded in Watson's Topographical Botany, ed. 2 (1883) (see p. 408), which was illustrated by a number of interesting specimens collected by himself.

Col. H. H. JOHNSTON also communicated a paper on Additions to the Flora of Shetland (see p. 429).

